FUNCTIONAL NERVOUS DISEASES

THEIR CAUSES AND THEIR TREATMENT

MEMOIR FOR THE CONCOURSE OF 1881-1883
ACADÉMIE ROYALE DE MÉDECINE DE BELGIQUE

WITH A SUPPLEMENT
ON THE ANOMALIES OF REFRACTION AND ACCOMMODATION
OF THE EYE AND OF THE OCULAR MUSCLES

BY

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Traditionem pondero, doctrinam respicio, sequor veritatem

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TO

DR. E. LANDOLT,

OF PARIS,

WHOSE MANY VALUABLE CONTRIBUTIONS,

TO THE SUBJECTS OF

MUSCULAR AND OF REFRACTIVE ANOMALIES OF THE EYES,

HAVE ENRICHED THE LITERATURE OF OPHTHALMOLOGY,

THIS VOLUME IS INSCRIBED,

AS A TOKEN OF HIGHEST ESTEEM

AND OF SINCERE FRIENDSHIP,

BY THE AUTHOR.

PREFACE.

This memoir, which received, from l'Académie Royale de Médecine of Belgium, the highest honor awarded for the competition of 1881–1883, is now presented in the English as it was then in the French language.

The thesis for the concourse was, "Élucider par des faits cliniques et au besoin par des expériences la pathogénie et la thérapeutique des maladies des centres nerveux et principalement de l'épilepsie."

Since this memoir was received by the Royal Academy, in December, 1883, many new views and experiences have presented themselves to the author, which he would have gladly included in this edition of the work.

This would have been inconsistent with the plan of giving it substantially in all particulars as it was submitted to the distinguished body which had already passed judgment upon it. It has been thought best to shorten the work in certain measure, and in

the revision thus made necessary the original form has been retained in every particular as far as possible, and while in a few instances such revisions have been made as were rendered necessary by the haste in which the original manuscript was prepared, the views and methods maintained in the original have been strictly preserved, without modification.

In order to introduce reproductions from photographs of some typical cases of neuroses in which the striking changes of physiognomy resulting from a relief to the tension of the eye-muscles in such cases is shown, the histories of these cases have been introduced. These histories, not in the original memoir, and obtained since its presentation to the Royal Academy, are indicated by brackets [ ], which in each instance permit them to be recognized as new material.

By an unfortunate occurrence, all the negatives from which these photogravеurs were to have been made were destroyed by fire while the work was being executed. It then became necessary to reproduce the portraits from very indifferent prints. Under these discouraging circumstances the result, although quite different from what was at first hoped, has been much better than might have been expected.

The supplemental portion of the work has been added, not for the expert in ophthalmology, but for

the general practitioner who would like to make such examinations of ocular conditions as will enable him intelligently to advise and to treat his patients affected with nervous complaints. That part of the supplement devoted to refraction and accommodation is made as comprehensive as possible consistent with brevity. In the treatment of muscular anomalies, much that is not to be found in the text-books on the affections of the eye is given. The subject has, in text-books, received but meager attention, quite insufficient to afford valuable assistance to one who would attempt the treatment of nervous complaints by removal of muscular defects. While the subject is treated here only in outline, it is hoped that the student of this subject will find here a better guide than has been elsewhere offered.

The author is indebted to the publishers for the skill with which the difficulties attending the reproduction of the portraits were overcome, and for the excellent manner in which they have presented the work.

33 West Thirty-third Street,
New York, *May*, *1887*.

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SUPPLEMENT.

INTRODUCTION.*

Pains spreading to parts contiguous to the eyes, as the result of strain to those organs, in much the same manner as pain from a wound extends to the environing tissues, have long been observed. In many of the older treatises on the diseases of the eye, headaches, nausea, and vertigo are mentioned as parts of that group of symptoms which we now designate as asthenopia.

It is to be remembered that the phenomena of accommodative asthenopia, while recognized, were, until its nature and causes were more fully explained by Donders in his remarkable work published in 1864, described under different names, such as *hebetudo visus*, *amblyopie presbytique*, etc., and were by many supposed to possess a distinct pathology, such as hyperæmia of the retina, or an increase of some of the humors within the eye. There was a general agreement, however, in the grouping of the phenomena and in regarding excessive or disadvantageous use of the eyes themselves as the exciting cause. The grouping consisted, as it now consists, of pain, tension in the

* Submitted to the Royal Academy of Medicine, July, 1886.

forehead, dazzling and confusion of vision, inability to continue the use of the eyes, to which by many authors were added the more general sensations of dizziness, nausea, headaches in other parts of the head than the forehead, and general *malaise.*

Antoine Maître-Jan * (1707) gives a good description of the complaint, which he thinks arises from increased intra-ocular tension resulting from strain of the eyes. A century later, Weller † (1832) enumerates tension over the eyes, headaches, nausea, and vertigo, to which train of phenomena Sichel ‡ (1837) adds insomnia, as the group of symptoms arising from excessive use of the eyes.

An old author, # in speaking of the people who require glasses for reading, but neglect to use them, remarks facetiously, "Their eyes ache, their head aches, and every bit of 'em aches." Piorry ^ (1850) quotes from his writings twenty years earlier, his views regarding certain nervous disturbances, "*oscillations nerveuses*" having their seat in the eye, the ear or in some branches of the fifth nerve.

A form of migraine which he calls "*irisalgie*" has, according to him, its origin in irritation arising either from the iris or from the retina. The migraine results in such cases from excessive or improper use of the eyes. He cites the case of a medical professor who

* "Traité des Maladies de l'Œeil," 1707, p. 260.

† "Maladies des Yeux, traduite par Riester," Paris, 1832, tome ii, p. 215.

‡ "Traité de l'Ophthalmie," etc., Paris, 1837.

Dr. William Kitchner, "Economy of the Eyes," 1824.

^ Piorry (1850), "Traité de Médecine pratique," tome vii.

habitually suffered from migraine after reading his lectures written in very fine characters, and who was free from the affection when he did not read the lectures. He also mentions the case of another physician who suffered severely from the same affection uniformly after several attempts to use glasses not adapted to his eyes. Piorry made no practical application of these views.

These few examples will serve to illustrate the extent to which the eyes were supposed to affect contiguous or more remote parts, up to the era when, by the discovery of the ophthalmoscope by Helmholtz, by the recognition of the *rôle* played by the ocular muscles in inducing fatigue about the eyes, a subject especially elucidated by Von Graefe, and by the discovery of *hypermetropia* by Donders, the knowledge of the causes and treatment of asthenopia was infinitely promoted.

Notwithstanding these great advances, the phenomena of asthenopia continued to be stated in much the same order as before.

Graefe and Donders enumerate the symptoms substantially as they are given above, and Stellwag* concludes his excellent description of accommodative asthenopia as follows:

"If the work is continued" (after the sense of exhaustion has commenced), "these feelings" (confusion of vision and swimming of objects before the eyes, with a feeling of pressure, fullness, and tension in the forehead) "soon increase to actual pain in and over

* Stellwag, first American edition, 1868, p. 622.

the eyes and are soon accompanied by a very painful feeling of dazzling; finally headache, dizziness, universal *malaise*, and even nausea occur."

Beyond question, however, the most important recognition of the fact that distant pain might be induced by straining the eyes was by Anstie,* who asserted that "functional abuse of the eyes" is a powerful source of irritation tending to induce neuralgia.

He also says that hyperopic sewing-girls are specially liable to that affection, and relates that he himself was relieved from neuralgia by desisting from the use of his eyes in reading.

Notwithstanding these assertions, Anstie seems to have made no practical application of the important facts thus enunciated, and even seems to regard the conditions as accidental and factitious.

Possibly a greater familiarity with the defects which are known to be influential in the production of asthenopia would have encouraged this learned author to make some practical application of a principle which he seems to have very imperfectly recognized.

Thus far, then, there had been recognized certain isolated facts concerning irritations arising from disadvantageous use of the eyes, in relation to parts somewhat removed from them.

No general principle of sympathetic or reflex irritation had, however, been formulated, and the first printed announcements of the existence of such a principle was made by myself, in a paper presented to the Albany Institute in the early part of 1876, and

* "Neuralgia," D. Appleton & Co., New York, 1872.

soon after in a paper read before the Academy of Medicine in New York, June 15th of the same year. The doctrine had, however, been publicly taught by me in lectures in the Albany Medical College two years previously to the reading of these papers, and several cases in which chorea and other nervous diseases were in relations of effects of ocular disturbances had been exhibited to my classes. Several papers relating to this subject have been given to the public by myself from time to time in which the doctrine has been somewhat more fully developed.*

A few writers have, since my first publications on this subject, recognized certain facts relating to it, but it can not be said that any contribution of considerable importance has been added to the literature beyond what has been stated.

If it is remembered that pain over the eyes, and even general headache, with feelings of general *malaise*, have been long recognized as among the occasional

* See "Transactions of the Albany Institute, 1874–1876"; "Chorea," "Transactions of the New York Academy of Medicine," 1876; "Refractive Lesions and Functional Nervous Diseases," "New York Medical Record," September, 1876; "Light in its Relation to Disease," "New York Medical Journal," June, 1877; "Clinical Notes of Cases of Neuralgia and Troubles of the Accommodation of the Eye," "New York Medical Record," October, 1877; "Relations between Corneal Diseases and Refractive Lesions of the Eye," International Medical Congress, Philadelphia, 1877; "Enucleation of an Eyeball, followed by Immediate Relief in a Case of Diabetes Insipidus," "Transactions of the American Ophthalmological Society," 1878; "Two Cases of Enucleation of the Eyeball," "Alienist and Neurologist," January, 1880; "Ocular Muscular Defects and Nervous Troubles," "Transactions of the New York State Medical Society, 1880; "Oculo-Neural Reflex Irritation," International Medical Congress, London, 1881; etc.

symptoms of asthenopia, it will be understood that, in the treatment of their asthenopic patients, oculists have from time to time casually relieved these more general symptoms while pursuing the rational measures of treatment for asthenopia. Such relief, incidental so far as the design in treatment was concerned, did not, in the minds of oculists suggest the principle that for such general symptoms not attendant upon asthenopia, the condition of the eyes should be examined, and perhaps treated. Thus, while Graefe recognized headache as one of the occasional symptoms of asthenopia, he did not suggest that persons subject to chronic cephalalgia should consult an oculist.

If the doctrines taught in the following pages should be accepted by the medical profession, doubtless many oculists might be able to recall relief to headaches as incidental to treatment of asthenopia. It would not be surprising even if the recollection of such an occurrence should induce in the mind of the practitioner the belief that he was then acting upon the principle here developed.

A careful and extensive search in the literature of ophthalmology and of general medicine has not enabled the writer to find any mention of the principle that irritations arising from ocular adjustments may act as reflex causes, inducing nervous troubles in distant parts, except in the vague manner already mentioned, prior to his own announcement of it.

Should the facts presented in this memoir appear to differ so essentially from the experience of medical practitioners generally as to seem to belong to the

marvelous, it can be said that they are all capable of being fully substantiated.

The author refers with pleasure to the several well-known medical gentlemen whose names appear in connection with some of the most typical cases here reported. He is sure that in every instance these physicians will affirm that these cases have been not only not exaggerated, but in every instance understated.

Surely we are not to hope for a specific against all neuroses. Our greatest advance must be in the recognition of some new classes of causative influences, and the means of combating those influences. If the author has presented to his profession one such new class of influences which shall be found of signal importance, his purpose will have been fully accomplished.

FUNCTIONAL NERVOUS AFFECTIONS.

In the study of nervous affections, the division of such disorders into functional and organic has long been recognized; and while these groups touch and mingle, so that no accurate boundary can be drawn between them, the division is nevertheless practical and necessary.

In the first group is found an extensive array of disturbances, characterized by diminution or increase of sensory or of motile power, or by a variety of other phenomena in which we find no evidence of an organic change, either of the nerve affected or of any portion of the central nervous system.

In the second group, distinct anatomical lesions are found, which may account for some or all of the peculiar manifestations.

There are certain obvious advantages in the study of the etiology of the first group. In case of structural degeneration of a portion of the nervous organization, should the true cause of the disturbance be found and removed, the degenerated structure may not re-

sume its normal function or physical condition, and the symptoms may continue.

On the other hand, if, in case of functional nervous disorder, the cause be removed, a reasonable hope may be entertained that the normal state may be resumed; and if the removal of a hypothetical cause is systematically followed by a cessation of the nervous disturbances, we have evidence of value that the hypothetical is the actual cause.

Two classes of influences are recognized as causes of functional nervous disorders, the more remote or predisposing causes and those which are immediate. The former, while frequently of insufficient intensity to originate neuroses, may, when the nervous disturbance has been once instituted, be sufficient to perpetuate it for an indefinite time. Immediate causes are perhaps rarely of a nature to induce long-continued nervous disorder, and in many instances, in which an occasion of disturbance may seem to be clearly indicated by the history of the affection, the influence of the supposed cause may long have passed away, while a pre-existing cause may be continuing the disorder. This fact can not be too clearly recognized in the study of this class of affections.

It may, for instance, be of little practical importance that a child first manifested symptoms of chorea while under the influence of fright. The evil has been accomplished, and the event can not be recalled, nor can such an influence be regarded as permanent or of long continuance. Hence, if the child continues to manifest the symptoms of chorea, it is reasonable to

search for an underlying cause which is permanent or continuous. Otherwise, it would be necessary to assume that, as a result of the immediate cause, some radical disarrangement of nervous action originated which perpetuates itself.

Such radical disarrangement has not been demonstrated, nor is its existence at all probable. The hypothesis, therefore, that there is an underlying cause of disturbance becomes stronger in proportion as the idea of a radical disarrangement is surrendered. Such underlying causes are fully recognized by students of nervous disorders, and their existence is so constantly verified by the daily experience of medical observers that their importance can not be questioned.

Persons in whom such underlying causes exist are said to possess a *neuropathic predisposition*, and individuals subject to this unfortunate predisposition are liable, from trifling immediate causes, to suffer from neuroses which manifest themselves in a great variety of ways. Thus, one individual will, as a sequel to almost every unusual emotional or intellectual excitement or depression, suffer from headache; another will, with atmospheric changes so slight as to be little regarded by most persons, habitually "take cold."

One result of the many careful observations which have been made respecting this neuropathic predisposition has been to demonstrate that in a very large proportion of instances it is hereditary; but that the hereditary tendency does not necessarily transmit the identical form of neurosis, and that any one or more of a variety of kindred affections may arise as the

result of the tendency. This important principle is illustrated in innumerable instances in which individuals suffering from a special form of nervous disease are able to trace the same or some quite different form of nervous trouble in parents or relatives. Thus, in one habitually subject to neuralgia, a family tendency may be found to various neuroses, such as chorea, epilepsy, oft-recurring nervous headaches, or possibly insanity.

Anstie, who has made special and extensive inquiry respecting this tendency, finds that neuralgia, insanity, epilepsy, paralysis, chorea, a tendency to uncontrollable alcoholic excesses, and phthisis are among the group of disorders which, through hereditary tendency, may manifest themselves either in the same manner or interchangeably.

The nature of such predisposition has not been recognized to an extent equal to its importance, and it will be one of the objects of this essay to point out a physiological group of circumstances which, beyond a doubt, constitutes a most important factor in this tendency. The great value of the knowledge of this factor in the predisposing tendency will appear when it is stated that this group of physiological circumstances is capable of such modification as to render it in most instances comparatively harmless.

Of immediate causes of neuroses, there is so great a variety that any attempt at an enumeration would be futile. Among the more frequent and important, however, may be mentioned the depressed conditions of the nervous system after recovery from exanthem-

atous diseases, severe and long-continued mental or physical strain, excessive emotional excitements, physical shock, and sudden and extreme changes of temperature.

The effect of these and many other exciting causes must, in the nature of the case, be transitory, and, independently of some more permanent influence, can rarely if ever account for long-continued and especially for intermitting forms of nervous diseases.

Another class of causes should be recognized as exerting marked influence in nervous disorders. These may be designated "*modifying tendencies.*"

Among these may be mentioned the influence of vitiated atmosphere—the so-called malaria; the period of life; the performance of certain physiological functions, especially those peculiar to females; and the nature of the employment of the individual. Thus, one subject to recurring headaches, while residing in a malarial region, may find the paroxysms so modified as to resemble attacks of malarial fever. The period of recurrence of migraine or of ordinary headaches is in a considerable number of females governed by the recurrence of certain physiological periods.

It must be evident that, whatever may be the exciting cause of a neurosis, it must, under the great majority of circumstances, be of infinitely less consequence than the influence which leads to it and perpetuates it.

The predisposing influence not only tends to prolong the disorder, but in a vast number of instances, when a certain form of disorder is supposed to be

cured, individuals subject to the neuropathic predisposition will become the victims of some other nervous disease. Individuals affected by one form of nervous disorder at one period of life are especially liable to suffer from some other form at another period. Thus, chorea in most instances runs its course in the space of a few weeks, but the person who has been a victim of this affection in early life will be likely to suffer from neuralgia or headaches, and sometimes from epilepsy, in later years. Hence, the predisposition is one which is a constant element in the organization of the individual, and may be the same for different forms of disorders; and, moreover, the cure of one complaint may be only the signal for the commencement of another; or, more correctly, the supposed cure of one form of disorder may be only a change in the manner of manifesting a permanent irritation.

These principles being accepted, it is important to inquire whether such a predisposing cause must be general, pervading the whole organism, thus affecting the whole nervous system; or must it at least necessarily find its seat in the nervous centers; or may it be entirely local, affecting directly only a limited number of nerves?

To this question the answer may unhesitatingly be given, that the predisposing or irritating cause may be wholly local, and confined to any portion of the central or peripheral nervous system.

An irritation set up in any nerve gives rise to the greatest variety of disturbances in any or all other

parts of the organism, however distant. Hence it is not logically necessary to suppose a universally pervading or even a central initial irritation in order to explain the neuropathic predisposition. The experiments of Sir Charles Bell, of Marshall Hall, and of many subsequent observers, have so clearly proved this doctrine that it is beyond question. Dr. Brown-Séquard, in enumerating some of the effects of tickling the sole of the foot in a large number of subjects, speaks, among other things, of laughter, of tears, of jerks of one or both limbs of a side, or of all the limbs, of tremblings and spasms, while in some instances no effect was manifest.

If it be admitted that the neuropathic predisposition may consist of a local irritation and not necessarily of some peculiar and undemonstrated general "modifications of molecular arrangements," we are prepared to inquire whether, inasmuch as this tendency is transmitted from parent to child, the evil may not consist of some peculiarity of anatomical structure, or of physiological adaptations, which is inconsistent with the most regular and easy performance of the function of a part or parts?

This would unquestionably be a reasonable hypothesis, and we are at once led to inquire whether mechanical or physiological peculiarities of this sort are likely to occur in a sufficiently uniform manner to enable us to classify them and to determine to which, if to any class, any very considerable number of irritations may be attributed; or whether, in other words, certain classes of mechanical peculiarities are more

than usually liable to become factors of physiological disturbance.

Manifestly, any hypothesis which assumes this must, to be sustained, be based upon many and long-continued observations conducted in a spirit of judicial independence, and free from all such bias as might result from occasional and exceptional experiences.

It is believed that the views advanced in this essay are thus based, and that a just regard for the experiences and teachings of all who have contributed to this important subject has been observed.

The conclusions here announced are based upon observations in twenty-six hundred and ninety-two cases of nervous diseases in private practice and of a considerable number of cases in public institutions,* which have been made with as much care and precision as the exacting demands of an active professional life would permit.

That in the course of these observations individual cases have failed to receive due attention is doubtless true; but that in the general results of this investigation the conclusions reached are accurate, the author believes that he can affirm without presumption.

In the confirmed belief that the neuropathic predisposition must of necessity be the manifestation of many structural peculiarities located in various parts of the organism, any of which may descend from parent to child, but which do not necessarily so de-

* Up to the time of writing, in 1883.

scend, and fully appreciating the influence of such immediate and modifying causes as have been already mentioned, the conclusion arrived at in this investigation may be stated in the following proposition:

Difficulties attending the functions of accommodating and of adjusting the eyes in the act of vision, or irritations arising from the nerves involved in these processes, are among the most prolific sources of nervous disturbances, and more frequently than other conditions constitute a neuropathic tendency.

A doctrine so much at variance with the ordinary beliefs must, of necessity, excite suspicion that the proposition has been based upon insufficient data, or that observations have been imperfectly made. That neither of these suspicions is correct it is hoped may be demonstrated to the entire satisfaction of reasonable inquirers.

If to the reader the proposition appears extreme, and tending, at best, to the recognition of a single class of causes to the exclusion of others, he is cautioned to observe that the proposition fully recognizes any and all causes of nervous irritation, and that the influences indicated by it are held to be pre-eminent, but not exclusive permanent causes.

If, in this discussion, greater importance will be conceded to these than to other influences, it will be from no unmindfulness of the possibility of other conditions acting as irritating influences, or that certain known or unknown agencies may give character to the results of irritation arising from the influences here specfied.

Let it be remembered that it has been universally conceded that the nature of the neuropathic tendency is unknown.

If one pre-eminently important element of that tendency is here demonstrated, it is not to be rejected because it may not include the whole.

In the explanation of the etiology and treatment of disease, neither settled theories nor novel doctrines can be proved, except as they are confirmed by undoubted facts. Nor can isolated facts, nor facts divested of their natural environments, be accepted as valid evidence in support of theories, old or new. The facts must be uniform, occurring so regularly as sequences as to demonstrate that they are consequences. Unless the skilled observer is able to predict with a reasonable degree of accuracy the result of certain combinations of circumstances, such results must be considered accidental.

Before presenting facts upon which this proposition is based, it will be well to inquire whether it is reasonable to suppose that irritation sufficient to cause or perpetuate a long-continued series of disordered nervous phenomena can arise from the performance of the functions of the eyes, and, if so, what is the origin of the supposed irritation?

In order to arrive at a fair understanding of this subject, it will be in place to review some points in the theory of adjustments of the eyes in the act of vision, which, although well known to oculists, may be less familiar to those not specially engaged in examining the defects of vision.

When rays of light fall upon the transparent surface of a healthy eye, they pass beyond the surface, through the pupil, and through the transparent media to the retina. If a distinct image is formed, the rays must unite at the focus of the eye, which is the retina. To this end, the rays are refracted as they pass through the media. In the normal eye the refractive power is such that parallel rays, rays from objects at infinite distance, unite precisely at the retina. If objects are to be clearly perceived at different distances, it is obvious that some provision must exist for changing the focus of the eye; for, while rays from a distant object are parallel, those from near objects diverge as they proceed from the object to the eye. These diverging rays must be more strongly refracted, in order to meet at the retina, than parallel rays. In the refracting media of the eye there are different factors; they are the anterior surface of the cornea, the anterior surface of the lens, and the anterior surface of the vitreous humor. The relations of these parts and the retina may be briefly described as follows:

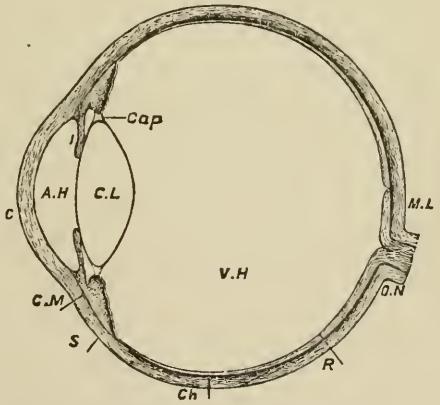

FIG. 1.—Diagrammatic section of the eye. *s*, sclera; *c*, cornea; *i*, iris; *ch*, choroid; *r*, retina; *ah*, aqueous humor; *cl*, crystalline lens; *vh*, vitreous humor; *cap*, capsule; *on*, optic nerve; *ml*, macula lutea.

The tough protective shell of the eye, the sclera, maintains the form and holds in place the transparent humors which fill its space. At the front of the eye-ball this hard coat is so modified in structure as to constitute the transparent cornea. Behind this transparent substance is the curtain, the iris, near the center of which is an opening, the pupil. The crystalline lens lies behind the pupil, and the considerable space behind the lens and in front of the retina is occupied by the vitreous humor. Light from a luminous object passes through the cornea and pupillary opening, then through the crystalline lens, and thence to the retina.

Now, in order to maintain such a condition of these refracting media that objects at different distances may be seen accurately, there must be some change in the relative refracting power; in other words, the eye must be capable of altering its focus.

In the well-known optical instrument, the opera-glass, the focus is adjusted by turning a screw, so that the lenses approach or recede from each other; in the eye the change is produced by alterations in the convexity of the crystalline lens through the action of the ciliary muscle upon it. The lens is held in its relation to the muscle by its delicate envelope, the capsule, and the muscle is capable of contraction under the influence of the will, in which case the opening becomes smaller. When this happens, the lens, by virtue of its elasticity, becomes more convex, and its refracting power is increased.

When, on the contrary, the muscle returns to a state of rest, the inner border approaches the outer

border, the opening is enlarged, and the lens, compressed by the greater tension of the capsule, becomes less convex. In the former case it is said to be accommodated for near points, in the latter for distance; and the power of thus changing the form of the lens, and consequently the focus of the eye, is called the function of accommodation.

This function of accommodation is always brought into use when the eye is directed to points at different distances from it.

If the eye is of the most perfect form and the media in the most perfect condition, this function is performed with ease, the ciliary muscle having abundant strength to execute the changes to any reasonable extent without undue fatigue.

But it so happens that this function is not always performed in this easy and regular manner. Eyes are not all constituted in the most perfect fashion, nor does the crystalline lens always maintain a uniform degree of elasticity; hence, not infrequently the ciliary muscle is called upon to perform an amount of labor quite exhausting; or it may be, on account of certain irregularities in the demands upon it, the muscle is subjected to a perplexity or fret from which it is easily exhausted.

Some of the defects in the form of the eye which have an influence upon the accommodation may be easily comprehended by comparing certain well-understood anomalies with the ideal, or, as it is called, the emmetropic eye.

In the emmetropic eye parallel rays are so refract-

ed that, without an effort on the part of the muscle of accommodation, they meet at the back of the eye.

This normal eye is, then, in a passive condition or state of complete rest when looking at a distant ob ject; but as the object approaches within what is called "finite" distance, which in ophthalmology is within six metres, the act of accommodation must be exercised. This in the ideal eye demands a moderate muscular exertion.

But in the hypermetropic eye, which is a short eye,* the refractive media are not sufficient to bring parallel rays to a focus at the retina. In such an eye the rays, if permitted to pass beyond the retina, would unite in a focus behind it. In such an eye, clear vision can only be obtained by giving to the rays a greater refraction than occurs when the eye is passive. Such additional refraction might, if no other means existed, be supplied by a convex lens, but ordinarily the object is attained by causing the crystalline lens to assume greater convexity—in other words, by the act of accommodation.

In the hypermetropic eye, then, accommodation must be exercised even in looking at the most distant object; and as long as the eye continues to see clearly at any distance, this exertion must be continued. If the object to be seen is near the eye, the effort must be excessive. Hence, such an eye is never at rest when seeing at all, and is performing excessive labor when looking at near points. In a certain proportion of hypermetropic eyes the ciliary muscle, even

* The "short eye" must not be confounded with "near-sight."

by the highest exercise of its power, is unable to accomplish the task of accommodation, and such eyes obtain no clearly defined images except by artificial aid.

The myopic eye, on the contrary, is too long, and parallel rays refracted in the same manner as in the emmetropic eye cross before reaching the retina. Circles of diffusion take the place of distinct images when distant objects are to be viewed, and, except for objects brought within the focus of the eye, vision is materially impaired.

Again, the refracting surfaces of the eye may be irregular in their curvature, in which case a pencil of rays will not be brought to a point. This irregularity is often found in the cornea. The curvature in one meridian may be greater or less than in that at right angles to it. In this case we have a condition called astigmatism.

These errors are called errors of refraction; and there are other defects which relate more especially to the act of accommodation. Thus, after the age of fifty, the crystalline lens in the best-formed eyes has lost so much of its elasticity that the act of accommodation for near objects becomes quite difficult, and this difficulty increases year by year, until at the age of seventy the function of accommodation is practically lost. Debility or paralysis of the ciliary muscles may also cause difficult accommodation.

To illustrate the effect of these and other defective conditions of refraction and accommodation, a single condition may be selected as an example.

The effects of hypermetropia can perhaps be more easily understood than the effects of other errors. For that reason, and not because of its greater importance compared with other anomalies, these effects are more fully discussed here. An examination of the results of this condition must serve to illustrate the disadvantages of the other anomalous conditions, notwithstanding the fact that the disturbances from the different conditions arise in various ways.

As it has been shown, the hypermetropic eye is short, and rays of light do not come to a focus at the retina without an effort of accommodation. If the degree of hypermetropia is moderate, and the ciliary muscle is vigorous, objects at a distance (in the examination of visual conditions a distance of about six metres or more is called infinite distance) may be seen clearly without any perceptible strain upon the eye. If, however, the eye is directed for considerable periods of time to near objects, as in reading, the muscle is overtasked. All know how a light weight seems to grow heavy as one holds it in the hand while the arm is extended. In the same manner the continued and unnatural tension of the ciliary muscle of the far-sighted eye may become at length a source of much weariness, and it is also seen that while the normal eye is at rest when accommodated for distance and only slightly exerted when accommodated for near points, the hypermetropic eye is never at rest except when closed. But a condition of much more importance than the simple continued strain of muscle is found in hypermetropic vision.

When the two eyes are fixed on an object, the image of the point fixed is at the yellow spot in the retina, and lines drawn from the yellow spot of the retina of each eye through the center of the pupil would meet at the point fixed. If the eyes gaze at an object at the horizon, these visual lines will be practically parallel; but if their view is fixed upon a near object, these lines are converged. The converging of the eyes is seen when one looks at a pencil held a few inches in front of the face. This convergence is effected by long, straight muscles located in the orbit and attached to the outer shell of the eye. There are several of these long muscles, but for our immediate purpose only two belonging to each eye may be mentioned: the external rectus, or straight muscle, which tends to keep the visual axes removed from each other; and the internal rectus, which tends to converge these axis. If the lines converge exactly in proportion to the proximity of the object, single vision is obtained with the two eyes. This associated or binocular vision is essential to exact notions of the position of objects in space, and, if not maintained, much confusion of impressions results.

It will at once be seen that the degree of accommodation of the eyes singly, and of the convergence of the optic axes, must be in harmony. For if the accommodation is fixed for one point while the convergence is for a point of greater or less proximity, there must result an absence of perfect definition, or the presence of double images. Hence the effort of the ciliary muscle in accommodating, and of the recti

muscles in convergence, must be not only simultaneous, but in precise proportion to each other. This being the case, a pair of normal eyes, accommodated for a given distance, will converge for the same distance. These muscular efforts are directed and regulated by nervous impulse, and in this case the impulse is exactly proportioned. Reverting now to the hypermetropic eye, it will be seen that a greater nervous impulse and more active muscular contraction must occur in accommodation than in the normal eye. Let it be supposed that the muscular effort of accommodation for a point one metre distant for a given hyperopic eye is equal to the effort in the normal eye for a point situated at half that distance; then if the effort at convergence equals the effort at accommodation, and the eye is focused for a point one metre distant, the axes of the two eyes will meet at a point not so far removed, and the eyes are not in their axes adjusted for the point for which they are individually focused, and confusion results.

In such a case continual compromising adjustments must be made and great nervous perplexity and disappointed nervous action must occur, for no sooner is one part of the adjustment corrected than the other is wrong. It is to this nervous perplexity, more than to the actual strain of muscle, that the weariness and pain characteristic of hypermetropia are due.

The principle just stated may be illustrated by the experience of young persons who, having normal eyes, attempt to use strong magnifying spectacles.

At first a sense of slight inconvenience is felt; but, if the attempt be continued for a considerable time, vertigo, nausea, and vomiting may result. This result does not occur if one of the eyes is closed. Hence, the disturbance is in the confusion arising from efforts at perfect binocular vision. But precisely this confusion of effort exists in the hypermetropic person, and if the continuance of such a course of perplexity for a few minutes or hours will result in so serious nervous disturbance as is shown in the illustration, is it not reasonable to suppose that a similar confusion of effort continued through many years may constitute a permanent source of nervous irritation? Similar perplexity results when either the internal or external recti or other long muscles are insufficient to the performance of their functions by the normal nervous impulse. A difficult and more complicated perplexity arises in case of astigmatism, and still other nervous confusion is the result of myopia. Hence all these abnormal states, whether from defects in the form of the eyes, or in the motor apparatus involved in associated movements, may give rise to nervous perplexity and irritation. But it has been shown that the effects of such perplexity or irritation in one part may be experienced in a distant part, and this principle is illustrated in the case of the young person who may induce vomiting by using magnifying spectacles.

However reasonable such a theory may appear, it can not be accepted as of practical value until it is shown that practical results may be deduced from its

application. I shall attempt to show that such results may follow with a surprising uniformity — first, by citing a single instance illustrating the effect of correcting each of the more commonly recognized defects of refraction and association; second, by considering at greater length several of the more familiar conditions of nervous disturbance; and third, by attempting to show the results of such corrections in a given number of consecutive nervous disorders of serious nature.

The first observation is the case of a lad aged seven years, whose mother brought him for treatment of the eyes in 1873. The immediate reason for the consultation was pain experienced in and above the eyes. He was nervous, suffering severely from chorea, from which he had not been free for two years. He was weak, had no inclination for the amusements of childhood, and was often ill in various ways. He was found to have hypermetropia in high degree. Appropriate glasses were directed, which greatly pleased him. Recovery from his nervous troubles commenced at once. The change was rapid and remarkable. The lad continued to gain strength, and was, within a few weeks, in all respects in better health than ever he had been before. Although ten years have passed, there has been no return of nervous troubles.

A lady, aged twenty-one, had suffered so greatly from facial neuralgia during many years that, among other radical measures for relief, she had submitted, by medical advice, to the extraction of all her teeth, notwithstanding they were sound. She was found to

have astigmatism, and strong cylindrical glasses were prescribed. The neuralgic paroxysms ceased within a few days, and have not returned during eight years.

A gentleman, aged twenty-eight, an extremely neurotic subject, was seen in January, 1877. He had for several years suffered from dorso-lumbar neuralgia. He was extremely sensitive to the influence of cold. A slight draught of air impinging upon the back was sufficient to bring on a paroxysm so severe as to confine him several days in his bed. He slept poorly, and so excessive was his general nervous derangement that he sometimes felt himself upon the boundary of insanity. He belonged to a neurotic family. His mother died insane. One of his brothers was insane, and a sister had been an invalid for several years from some nervous disorder. He was myopic, with a slight astigmatism. Glasses to meet these conditions were prescribed and used. Nine months later he called to say that he was entirely cured, and that the relief had been immediate.

A lady who had suffered from facial neuralgia of intense character during many years, was found to have insufficiency of the internal recti muscles. Tenotomy of one of the external recti was performed, since which time, although six years have elapsed, she has had no attack of her complaint.

These instances serve as illustrations of irritation arising from uncomplicated errors of refraction, or of association, and of the relief often obtained by the correction of these uncomplicated errors.

But it often happens that these anomalies are not

uncomplicated. Thus, refractive errors, such as hypermetropia or myopia, are often associated with muscular insufficiencies, either of those directing the eyes laterally, or of those which move them in the vertical direction. Again, insufficiency of either of these muscles may be associated with weakness of the muscle of accommodation. These are but a few of the complications which may be found, and, in many of these nervous complaints in which the predisposing irritation is found in the eyes and their motor apparatus, the simple correction of a refractive error is by no means sufficient to bring relief to the nervous condition. When once a neuralgic, choreic, or epileptic habit has been long established, not only may it be necessary to remove the principal source of irritation, but all irritation, before the habit will be discontinued. It must not, therefore, be supposed, even if the hypothesis that refractive and muscular errors of the eyes constitute a very important factor in the neuropathic condition, that the simple adjustment of a pair of glasses, or the simple relaxation of a muscle, must of necessity establish the cure of a nervous disease.

The irritation experienced in and about the eyes, and in the forehead and temples, as a result of ametropia or muscular anomalies, is called asthenopia. It is a complaint for which oculists are very frequently consulted, and doubtless yields more readily than complaints arising from the same cause more distantly located, or of more severe nature; yet it is well known to oculists that even asthenopia does not al-

ways yield to such simple measures as have been mentioned.

Hence the highest skill and most patient effort may be demanded for the removal of ocular disturbances which may cause nervous troubles, and the failure of efforts directed only to some prominent ocular defect would not of necessity argue against the probability that the eyes may, after all, be the seat of trouble.

Bearing this in mind, we are prepared to examine more in detail a few forms of neuroses and their relations to ocular defects.

CEPHALALGIA OR HEADACHE.

The form of nervous disturbance more common than any other, perhaps, is headache. The habitual sufferers from this complaint are everywhere, and, inasmuch as the subjects of the disorder are usually able to be about, and generally to attend to the ordinary duties of life, they are forced to surrender themselves to the ever-returning torture with as much resignation as possible; and, after trying many remedies, almost all of which may, for a brief period, seem to modify their sufferings, they at length submit passively to their fate, with the comforting assurance that the disorder is constitutional, and that nothing can be done.

Although headaches take a variety of forms, an outline of the most characteristic features of the disorder may be drawn in such a general manner that the details of the picture may be easily filled in for an individual case.

The pain most usually attacks the temples, the supra-orbital and the occipital regions, the parts within the orbit, and more rarely the top of the head. It is more or less paroxysmal, sometimes occurring with comparative regularity, but frequently arising after a period of anxiety, care, worry, or excitement. In many cases the pain is continuous, and paroxysms consist simply of increase of the ordinary suffering. In the majority of females examined who have been habitual sufferers from headache, there has been found habitual pain at the origin of the trapezius muscles, at the point over the extremity of the spinous process of the seventh cervical vertebra, and at the lower angles of the scapulæ. Less common, but quite characteristic pains accompanying headache are between the angles of the scapulæ and at the lower part of the dorsal region. It is worthy of observation that in general, if pain is habitually experienced at the lower angles of the scapulæ, it is rarely found at the point over the spinous processes of the vertebræ situated between those points; and, again, if pain is habitual over the spinous process of the seventh cervical vertebra, it may be presumed to exist, although it is not invariably found, at one of the other locations below it. These pains occur much less frequently in men, who, more than women, suffer from dull pains at the occipital region. This occipital pain, which is invariably located in the scalp and occipital muscle, is very frequently and incorrectly spoken of, sometimes even in medical literature, as "pain at the base of the brain."

Other sympathetic pains are, at the turn of the shoulders and along the course of the triceps muscle, and in the upper portion of the chest.

Patients suffering from headaches are frequently dyspeptics; they often suffer from insomnia, and habitual constipation is also a not infrequent attendant condition.

To the various conditions just named, the headaches are often attributed, and many patients feel sure that they can account for their headaches as of stomachic origin, because they habitually suffer from disturbance of the stomach at the time of, or just before, the paroxysm of headache. That these are simply attendant symptoms and not causative influences, will be seen as we advance, and the fact that an indiscretion in diet, or an enforced loss of sleep, may act as an immediate cause, will be found to be explained on the principle of increased demand upon nervous energies already rendered inadequate to the ordinary demands of the system, and that this increased demand acts in the same manner as would other calls upon the nervous energies.

Habitual sufferers from headaches, although often persons of highest mental culture and of superior intellectual endowments, are liable to suffer from chronic lassitude and inaptitude to set themselves about any employment, especially if it demands much mental exercise. In some cases a confusion of ideas is so conspicuous a symptom that patients express fears of approaching insanity. There is, in a large proportion of instances, a general nervous irritabil-

ity, inability to continuous exertion, and mental depression. Still other cases are so characterized by general impaired functional activity, that the principal local manifestation, the headache, is apparently a secondary subject of attention. Such patients exhibit symptoms varying in a considerable degree, according to the sex of the individual, and the cases are known as spinal irritation, neurasthenia, etc., conditions to which attention will be presently directed.

Chronic headaches are common among those who inherit a neuropathic tendency; by far the greatest number of subjects acquiring the predisposition by inheritance. Certain collateral influences modify the disease in a marked degree. Thus, a residence in a malarial district may give to the complaint a more distinctly periodical tendency, and subjects of headache passing an active life in the open air will, in general, experience less of the associated neuralgic pains in the back and sides than persons of sedentary habits.

The most important facts relating to the etiology of the complaint may be briefly recapitulated as follows: It is an exceedingly chronic disorder, often relieved temporarily, but rarely, if ever, permanently cured by medicines. It is often traceable to the earliest years of the patient. The tendency is frequently, if not generally, hereditary. It is usually intermitting, and demands upon the nervous energies, slightly in excess of those ordinarily required, act as immediate causes. We also find that other symptoms of nervous disturbance, such as insomnia, dyspepsia, and

pains in various localities, are frequent attendant disorders.

These facts lead to the conclusion that the cause is permanent, and in most cases commensurate with the life of the patient; that the irritation or exhaustion affects the nervous centers and is reflected to various parts at a distance from the head as well as to the head itself. Hence, the manifestations of nervous exhaustion or irritation are interchangeable. Thus it is that one in whom the irritation may have been for a long time exhibited as habitual headache may, from some reason, assignable or otherwise, afterward suffer from dyspepsia, neuralgia, or other forms of nervous disorder from the same irritation, and such a change in the form of disorder does not indicate a cure of the first disease, but only a different manifestation of the same trouble from the same cause.

We also find that certain modifying influences, such as the manner of life, the location of residence, and the occupation of the individual, contribute to lend certain characteristics to the complaint.

We are, then, applying all these facts, to search for some cause which shall most generally answer to all these conditions. It must be permanent, often inherited. It is not of necessity situated at the seat of pain, and is as capable of inducing pain or distress in one part as in another. Such a cause must be anatomical, and it is reasonable to assume that it acts by causing inordinate demand upon the nervous energies in the performance of some function or functions, thus reducing the ordinary standard of nervous power in

such a manner that slight additional demands cause marked irregularity of nervous action, permitting agencies which might not otherwise induce disease in the individual to become under these circumstances, capable of exerting important modifying influences. It may be said in general that any anatomical condition which would render the execution of an important and constantly performed function difficult might, by so reducing the amount of nervous energy, become a neuropathic predisposition.

This principle being established, it remains to determine, if possible, whether difficulties in performing any one function more often act as such predisposition, than those attending the performance of other functions.

This question can not be satisfactorily settled upon theoretical principles independently of practical results. If it should theoretically appear probable that this irritating or exhausting influence is to be found more frequently located in one organ or set of organs than another, and should assistance in the performance of the functions of that organ or set of organs be quite uniformly followed by a relief from the disturbances previously experienced, a reasonable ground would exist for concluding that the most general cause had been discovered.

It has already been shown that, in the performance of the visual act, difficulties of no insignificant character are very frequently encountered. These difficulties are often permanent, and are to a great extent hereditary. The nervous strain arising from visual

defects, organic or functional, is great in proportion as the present civilization makes greater demands upon the visual function than has any previous civilization; and the neuroses of the character which we are considering are notably more numerous at the present time than in former times. That this increase in nervous disorders is not a result of any deterioration of physical power among the civilized nations of the present time is apparent when we remember that the duration of life is now greater and the average capacity of labor is probably greater among civilized people of the present age than among those of former centuries.

If it can be shown that a very considerable proportion of chronic headaches are relieved by the removal of exhausting or perplexing conditions from the eyes, the theory that such conditions are among the initial causes will be established.

A few cases somewhat in detail will illustrate the manner in which such relief is obtained. These cases do not differ essentially from several hundreds of others, either in their general features or in the results of treatment:

Mr. W. N. B., consulted March 16, 1881. He has for six years past suffered extreme pain in the top of the head and in the occipital and temporal regions. He is never free from pain when awake. He is in an extremely irritable state, rests poorly at night, has more or less backache, and is always constipated. His face is usually flushed, although he is of strictly temperate habits; and

he is much troubled with vertigo. He has been forced to resign his position as secretary in a large public institution, and during the two months preceding his visit has been an inmate of an excellent hospital, where he has been under treatment. Although somewhat rested, he has obtained no relief from the nervous symptoms.

He was found to have hypermetropia 2·50 dioptrics, and insufficiency of the external recti muscles.

Convex glasses 1·5 D. were prescribed, which were soon replaced by convex 2·00 D. Partial tenotomy of one of the internal recti muscles was made, and the operation was soon followed by a similar one on the other eye.

The patient rapidly improved, and was in a few weeks able to return to clerical duty. This, however, he afterward resigned for a more active life, and his health has remained entirely good during the interval of two and a half years.

Mrs. J. D., aged fifty-seven, consulted February 24, 1881. Has had headaches since she was fifteen years old. Is a large, well-developed woman, apparently vigorous. Paroxysms occur at intervals of from once a week to once in two weeks. They are of great intensity, and not infrequently quite alarming to friends and physicians. In the intervals she suffers from sciatica, from mental depression, from dull headaches, palpitation of the heart, and dyspepsia. Two sisters are subject to chronic headaches.

Examination of the eyes shows that she has a

moderate degree of astigmatism and deficient adducting force.

Convex cylinders were prescribed and used with a combination of spherical and cylindrical for reading purposes, and the adducting power was increased by systematic exercise of the internal recti muscles with prisms.

March 23d, has perfect converging power. Has had no headache during the past two weeks.

April 10, 1883. Has during the interval of more than two years been entirely free from headaches. Has no more dyspepsia, palpitation, or sciatica, and her present call is only in regard to a change of reading-glasses.

Reference is made in the above case to exercise of the ocular muscles, which is accomplished by means of prisms which the ocular muscles are called upon to overcome in order to maintain single vision ; prisms of gradually increasing strength being employed.

As other references to such exercising of the ocular muscles will be made, it is proper to anticipate with a few words what will be stated more at length further on in regard to it.

Exercise having the same object in view and performed in a somewhat similar manner to that which will be hereafter described, was formerly employed to some extent for the relief of insufficiency of the internal recti muscles. As the experience of oculists generally proved that, in the majority of cases in which insufficiency arising from actual disproportion of the recti muscles exists, this is quite inadequate,

the exercise has been for several years very generally abandoned.

In the cases in which it is referred to in this essay, there has existed, for the most part, an insufficient adducting energy, but no very considerable degree of insufficiency such as would be shown by the dot and line test of Von Graefe.

The distinction between the two forms of insufficiency will be dwelt upon more at length in its appropriate place, and it remains only to say here that such exercise in suitable cases proves of infinite benefit. Hereafter the term "insufficient adducting power" will be used to describe the condition amenable to such exercises, while the term "insufficiency of the internal or external recti muscles of a stated number of degrees" will express the condition commonly described as insufficiency of the recti muscles.

The following case illustrates a very frequent cause of headache and of other nervous symptoms:

A young gentleman had for several years suffered almost continuous headache during waking hours. His plans of life had been seriously modified by the constant torture he suffered, and he was often in charge of a physician.

Deficient energy of the ciliary muscles in the act of accommodation was supposed to be the cause of his trouble. Tablets containing small quantities of extract of Calabar bean were placed upon the eyes daily for a few days in succession, followed by the occasional but less frequent use of the same agent for two weeks. At the end of that time he was greatly

improved, and in a month quite well of his headaches. Four years have passed with no serious return of his old complaint, and a threatened attack can be averted by a single instillation of a solution of eserine into the eyes.

Severe and long-continued headaches are sometimes accompanied by excessive symptoms of exhaustion, coldness of the extremities, and loss of muscular elasticity.

> Annie W., age ten years, was brought for examination in September, 1880. She had been always subject to severe headaches, located in the temples and back of the head. Although rarely free from suffering, her pains are greater if she attempts to look at books. She is very pale and thin; walks feebly, and seems quite exhausted with very moderate exercise. The facial muscles are so little active that she seems expressionless. Her speech lacks energy, and in all respects she seems to be in a state of great nervous exhaustion.

There was found in this case marked insufficiency of the external recti muscles and very slight adductive power when accommodation was relaxed.

After increasing the adducting power by exercise, partial tenotomy of the internal rectus was performed under the influence of chloroform.

The child commenced very soon to gain strength and elasticity; expression came to the face and vigor to the limbs; the headaches ceased and mental energy followed. She has continued well during the three

years, and is now advanced in her studies beyond most of her companions of the same age.

The two portraits of Plate I, reproduced from photographs, represent a child ten years of age, who from infancy had been the victim of headaches. She was feeble, always tired, and rarely free from pain. Attempts to send her to school had proved unsuccessful, for she no sooner commenced attendance than she became prostrated. She had insufficiency of the externi, and operations for its relief was made, upon one eye June 8, 1883, and upon the other June 12th. It is needless to tell one who examines these two pictures that the change was marvelous. The weary, heavy, discouraged aspect of the child as shown by the portrait of June 8th is in remarkable contrast with that of June 20th, where vivacity and courage are embodied in her expression. The child returned home to enter school, where she has done excellent work.

In the cases above cited, headaches have been relieved by the removal of irritation induced by— 1. Hypermetropia, with insufficiency of the external recti; 2. Astigmatism, with enfeebled adducting force; 3. Enfeebled energy of the muscles of accommodation; and, 4. Insufficiency of the external recti muscles uncomplicated with any very important refractive error.

It will thus appear that these various conditions of refractive and muscular anomalies may act as disposing causes of headaches, and that the removal of the

Plate I.

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2.

irritation arising from such conditions is sufficient to afford permanent relief to the nervous suffering.

The number of cases of chronic headache* in the private practice of the author, in which examinations of the ocular conditions have been made, is twelve hundred and eighty. For nearly all these, advice in regard to the correction of the ocular defects has been rendered; but, inasmuch as the period during which these examinations have been made extends through several years, it is manifest that it is impossible to know the result of this advice in all cases. A very large proportion of these are transient cases, in which a single consultation has concluded the relation of physician and patient, and as many of the cases reside in cities distant from the residence of the writer, some even of those who receive treatment for a longer time are lost to observation. In order, however, to arrive at some basis of facts from which one not in the constant observation of these phenomena may be enabled to draw some conclusion as to their value, an analysis of the results in one hundred consecutive cases of chronic headache is here given. The list extends backward from December 31, 1882, to the 2d of June of the same year. This, while allowing sufficient time to have elapsed since the most recent date, to determine the permanent results, is also sufficiently recent to enable a recollection of the cases in some measure to supplement the written record.

Proceeding, then, to the analysis of these cases, it

* Chronic in the sense of continuing during more than one and in general during several years.

is found that of the number, nothing is known of the patients after their first consultation in twenty-two cases. In five other cases, in which more than a single visit was made, no knowledge of the subsequent history is possessed. Sixty-one are known to have obtained permanent relief. Nine are known to have received temporary and marked improvement, while in three cases no improvement resulted.

If we exclude the twenty-seven cases the history of which, since the examinations or after a very few calls, are unknown, we shall find that the proportion to one hundred is as follows:

Permanently relieved.....	83·6 per cent.
Improved.....	12·4 "
Not cured.....	4 "
	100

It should be observed, in passing, that the cases upon which these statistics are based are in all respects typical cases of chronic headache, of which the illustrative cases given above are fair examples. No cases of simple asthenopia or of temporary headaches are included.

It should be further remarked that in these cases drugs have not been administered, except in rare instances, for temporary relief of some other symptom, and in no case can the influence of drugs be regarded as a factor in the result of the treatment. This statement will also apply to classes of cases hereafter to be reported. In fact, the results in these cases must be attributed solely to the removal of the

difficulties incident to the performance of the visual act.

As has already been said, every oculist recognizes the fact that asthenopia is a complaint resulting generally from ocular defects or insufficiencies of the ocular muscles. Yet it is equally well known that this more immediate and much less severe form of irritation does not always yield to the means employed for its treatment. But if we compare the results of treatment of asthenopia with the results obtained in the treatment of headaches by similar means, we can not fail to see that the latter form of complaint yields as often to treatment directed to correction of anomalies of refraction and accommodation or of muscular insufficiencies as does the former. Hence we may logically draw the conclusion that headaches are as generally the result of disturbing ocular conditions as is asthenopia.

It is to be further observed that the relief is not the result of temporary stimulation of nervous energy, such as might result from the use of electricity, or of certain drugs, or a change of air or surroundings. Either or all of these measures might bring relief in certain cases, but if the fundamental cause remains, it is only relief, and can not be properly regarded as a cure, of the predisposing tendency.

In cases of temporary nervous disturbance, resulting in headaches, the agencies above mentioned may be used with advantage, but they certainly have no power to remove an hereditary cause.

Further consideration of the treatment of this

special class of troubles may be reserved for consideration under the general discussion of therapeutical measures in nervous complaints.

Nearly related to this class of troubles is migraine, a complaint often classed with neuralgia, but which has characteristics so clearly defined that it may well rank as a distinct form of nervous disturbance.

MIGRAINE, OR SICK-HEADACHE.

Paroxysms occur with greater or less regularity in respect to time, the intervals being in some cases only a few days, in others a month or more. The attack commences in most cases with a feeling of lassitude and dull headache, the eyes are painful, and the act of turning them quickly or far is attended with distress. The effect of light is disagreeable, and there is mental disquietude. In some instances the attack is ushered in by great disturbance of vision, sometimes described as glimmerings and confusion. At other times the visual defect assumes the form of hemiopia, or even of complete blindness. The visual disturbance lasts from a few seconds to an hour, and such attacks are known as "blind headaches."

The subject of an attack, after a few hours of these premonitory symptoms, resorts to the bed, the pain over and through the eyes becoming more and more intense, and the effect of light more tormenting. Slight sounds or feeble currents of air are often unendurable, and nausea and vomiting supervene. The pain is in many cases confined to one side, and in some uniformly to the same side, in various attacks. In others the

pain is alternately located on one or the other side, and, in case of visual disturbance of one eye only, the headache is often situated upon the opposite side of the head to the eye affected. The headache as well as the visual disturbance may, however, be bilateral.

In a few cases of "blind" headaches, in which the fundus of the eyes have been examined with the ophthalmoscope *during the period of visual disturbance*, the retina has been found pale and brilliant, the optic disc unusually white, and the main arteries somewhat irregularly contracted in their course. In these cases the field of vision has been found to be contracted in a striking manner, in some instances one half of the field being completely lost, while in others the central field was gone, imperfect sight only remaining at the periphery.

A night's sleep may bring relief, or the paroxysm may continue for several days, during which delirium or loss of consciousness may become prominent symptoms.

The attack being over, there may remain some symptoms of the nervous prostration for a day or two, but the patient is soon more than usually well for a period of one or several days, and the subjects of the complaint are often extremely vivacious and energetic in the intervals between the attacks. This is, however, not always the case, as a certain proportion of the subjects of this malady are rarely free from a dull headache, pains at the spinous process of the lower cervical vertebra, and at the lower angles of the

scapula. Palpitation of the heart and general nervous irritability are also among the continuous symptoms.

The history of the affection often goes back to the earliest recollections of the patient, and in nearly all cases a vast number of supposed remedies have been tried, sometimes with slight temporary relief, but more frequently without any good results. In a considerable number of cases the affection is developed during school-days, a circumstance which has led to the abhorrent supposition that it results mostly from impure thoughts and practices.

Fortunately, this is a gross libel upon a class of humanity on the whole characterized by frankness and intelligence. If we remember that, at the age of from eight to fifteen, nearly all of the children in whom this affection is found are at school, closely pursued by examinations and a multitude of studies, we shall see that the demand upon the ocular muscles is excessive, and that this demand is for the most part made in crowded school-rooms, where the air is vitiated, and nerves and muscles are thereby rendered less capable of enduring the strain. Again, these subjects of migraine are, as a class, unusually ambitious, and such children maintain advanced positions in their classes at an expense of eye-strain even greater than that which attends the exercise of the eyes of the less ambitious pupil. If, added to this, there is an anatomical or physiological reason for unusual strain in doing the ordinary work of the eyes, we have a combination of circumstances conspiring against the strength of these children.

This is not only the more true but the more generous explanation of the occurrence of these attacks, at this period of life, than the one alluded to; and the author, after a careful investigation of both sides of this question, feels justified in earnestly protesting against the unjust insinuation.

Some patients suffer less when absent from home, occupied in travel or repose, or when engaged upon light duties which permit them to be much in the open air. Tonic medicines also sometimes increase the intervals between the attacks and render them less severe. The temporary relief, however, which lengthens the intervals or modifies the attacks can not be regarded as a cure. And a cure can only be assumed when so long a period of time has elapsed since a last attack that, under ordinary circumstances, in the particular case, a very large number of attacks could reasonably have been expected. Again, as in case of most functional nervous diseases, there is a tendency to a change in the form of the complaint, and one subject for several years to migraine may find that he has no longer sick-headaches, but is a sufferer from some form of neuralgia, perhaps equally distressing with the former complaint. Such a case can not be regarded as cured. There has been simply a change in the manifestation of nervous irritation. In all these cases there is an underlying cause, which is to be found and removed. This accomplished, a permanent cure may be anticipated.

Here, as in the case of the more ordinary forms of headache, it will be found that ocular defects play a

conspicuous *rôle* as causative conditions in migraine. According to the experience of the author, these defects constitute by far the greatest factor in these cases. Unlike the ordinary forms of headache, however, migraine does not so frequently yield to the simple measures of adapting glasses to correct refractive errors. There is often a complicated state of refractive trouble and muscular insufficiency, demanding greater care and judgment in correcting the ocular conditions. With sufficient accuracy in relieving these defects, however, sick-headaches will, in the great majority of cases, cease.

The following are not only typical cases of sick headaches, but are illustrations of the ordinary results of treatment directed to ocular defects in a great number of cases:

Miss N., aged seventeen. November, 1880. Had during the past three years suffered greatly from "blind headaches." She was delicate, anæmic, suffering from nervous irritability almost characteristic of chorea, and quite unable to endure ordinary physical exercise. Paroxysms of headache occurred once or twice a week, and lasted one or two days. The onset of the attack was uniformly marked by a total loss of one half the field of vision and enfeebled vision in the remaining half of both eyes. The hemiopia was heteronymous, the temporal portion of the field of each eye being lost. After half or three fourths of an hour of this visual disturbance, which was associated with pain over the eyes and through the orbits, and with a general

sense of chilliness, the orbital and frontal headache became most intense, nausea followed, and the patient was forced to retire to her bed in extreme torture and prostration. Vomiting usually occurred, but not uniformly. If she could fall asleep, a night's rest might bring relief, but the attacks not unfrequently continued until after the second night.

During the period of visual disturbance of one of these attacks the eyes were examined, with the following results: The field of vision was contracted in all directions, but more especially in the outer portion, as shown in the diagram which represents the field of the right eye.

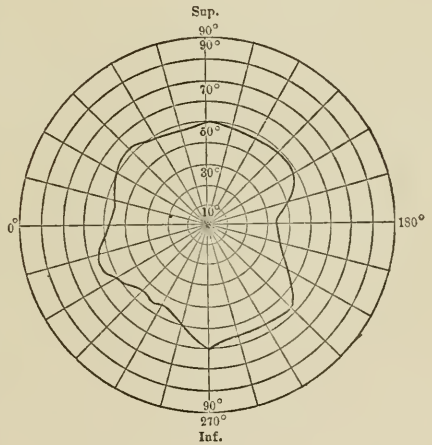

Fig. 2.

Vision was $\frac{20}{70}$, the letters of the trial-card appearing and disappearing. The ophthalmoscope showed the disc pale, the arteries rather small, the red cylinder of the larger being bordered with white lines representing the unusually conspicuous sheaths of these vessels. The veins were rather large. The general background lighted up well, but was of paler red than usual.

The young lady's mother, who had died in child-

birth, had, during several years preceding the time of her death, suffered from chorea, and her father was a neurotic subject.

No physical cause for these frequent and torturing nervous disturbances was found elsewhere than in the eyes and their appurtenances. She had a moderate degree of astigmatism, and very feeble adducting power.

Cylindrical glasses were employed to correct the astigmatism, and the adducting power was developed by systematic exercise of the muscles, until complete associative action was established. After about three weeks the headaches ceased entirely, her strength improved rapidly, and she was soon in excellent health. In June following a slight return of the trouble caused her to direct renewed attention to the condition of the eyes, when it was found necessary to renew the exercise of the ocular muscles for a few days. Since that time she has continued well.

Migraine not unfrequently alternates with intense neuralgic headaches in which nausea is absent, or the one form of trouble may replace the other permanently.

> Mrs. H., aged forty. February, 1879. Is an exceedingly active woman when well, but during nearly all her life has been subject to frequent and tormenting attacks of migraine, which during the past year have alternated with neuralgic headaches. She rarely passes a week without being confined to her bed from one to three days. As soon as the attack of headache or neuralgia is over, she is ready to drive out, and almost compensates

by her unusual energy for the time lost in bed. She is, however, rarely without pain in the head and back, and often passes whole nights without sleep. She has also for many years had neuralgia in the eyes and face. The eyes being examined, she is found to have hypermetropia manifest, 1 Dioptry, and to have markedly insufficient adductive power.

Convex glasses were prescribed and used, and the adducting power increased to the proper degree by exercise. The headaches and neuralgic troubles ceased when once this was accomplished, and during the several years intervening she has continued well.

Many patients from distant cities, or even those residing in the vicinity, after making one or two calls may discontinue their visits and make no report of their progress. Necessarily, in such instances, nothing can be known of the result of advice given, or whether the advice has been accepted. Some of these transients, however, make their appearance after longer or shorter intervals, and the result of the single interview is first learned by the physician, perhaps, after several years. The following is an instance of this kind:

Mr. J. F. de L., aged forty-five, consulted June 4, 1879, on account of sick-headaches of unusual intensity. Since early boyhood he has been subject to attacks occurring with great frequency, the interval between attacks being rarely as much as four and more frequently not more than two days. He describes the paroxysms as follows: Pain commences in the temples and forehead, and becomes

more intense and general until nausea and vomiting set in, when he retires to his bed. His wife spends the night in applying lotions and applications to his head, and bathing his feet in hot water. He is accustomed to take 1·5 gramme bromide of potassium with sulphate of morphia 0·1 centigramme combined, and repeated at intervals of one or two hours, with slight relief. The paroxysm, however, rarely continues less than twenty-four hours. He has spent much time in traveling in mild climates, hoping to gain relief, but has often returned worse than he went from home.

He was found to have astigmatism, corrected by lenses of the following combination: Spher. 0·50 D., cylind. 1 D., axis 90°, which were advised for constant use.

He was not seen again until June 28, 1883 (more than four years), when he called, saying that he had used the glasses prescribed, and had, during the four years, been almost entirely free from the tormenting affection which had followed him during a great portion of his life, but that within a few weeks he had suffered a few slight attacks. It was found that the spectacle-frames had become so bent as to give the cylinders an improper axis. The frames were bent into position, and the patient advised to observe care in keeping them so.

Only two cases are given as additional illustrations, the first without dwelling upon details. Both are typical cases of sick-headache:

Mrs. M., aged thirty-two. June 3, 1882. Dura-

tion fifteen years; attacks about once a week. Eyes trained two weeks.

October 7, 1883. Is in perfect health. Has not had attack of migraine since first week in June, 1882. No such respite has been known in past fifteen years.

Miss Alice S. was brought by her physician, Dr. William Stevens, October 2, 1882.

The patient is twenty-nine years of age. Is rather tall, of fine form, but thin in flesh and extremely pale. The lips are colorless and the ocular conjunctiva of pearly white. She has had migraine once or twice a week during the past nine years. The pain is always unilateral, attacking one or other eye and supraorbital region, and extending downward along the course of the branches of the fifth nerve. With each attack she is forced to retire to her bed, and intense nausea and vomiting are always present. A night's sleep often brings relief.

In this case there was found to exist compound myopic astigmatism (M. 3·50 D. + A M. 1·25 D), with insufficiency of the internal recti muscles 27°.

Glasses for correcting the refractive error were prescribed, and tenotomy of one, and soon after of the other, external rectus was made, fully correcting the insufficiency of the interni while maintaining full abducting power.

She has been seen from time to time, and careful observations have been made of the ocular conditions as well as of her general health. There continues

perfect adducting and abducting power, and the equilibrium test shows no insufficiency.

Her health improved from the time of the operations, the color returned to her face, she gained in weight and strength, and, although a year has passed, she has not had an attack of migraine.

The results of treatment of migraine, by the removal of, or assistance to, ocular defects, have been no less successful than of the more ordinary forms of headaches by similar means; but, as before intimated, migraine is frequently a manifestation of more complicated ocular conditions than the ordinary headache, and consequently greater care in discovering, and greater skill in removing, these defects may be demanded in this than in the more ordinary forms.

It is a fact worthy of consideration that the most violent and characteristic symptoms of migraine are directly referable to the orbit or its immediate surroundings.

We may well suppose that the paroxysm represents the last degree of perturbation of the nerves connected with the muscles of accommodation or of consensual movements, and that the pain in and about the eye and the intolerance of light are direct manifestations of this condition of incomplete surrender of their appropriate functions.

NEURALGIA.

Passing, now, to the consideration of neuralgia, we shall find not only close relations with the forms of neuroses already discussed, but that difficulties in the

performance of the visual act constitute an important causative factor.

Before proceeding to discuss the therapeutics of the disease, it will be well to determine, first, precisely what is meant by the word as used in this essay, in order that there may be no misunderstanding as to the character of the cases which may be adduced. The word neuralgia (from *νεῦρον*, a nerve, and *ἄλγος*, a pain) is in itself almost a definition. The great characteristic of the disease is pain, which is located usually along certain nervous trunks or their branches, not always confined to their peripheral distribution, but often following the whole course of the nerve. A single branch, or all the branches, of a nerve may mark the seat of pain. In its character it is usually of great intensity, rather sharply defined in its location, remitting or intermitting, not necessarily attended with any vascular excitement, although pyrexia sometimes accompanies the paroxysm.

Attacks sometimes commence in the most sudden manner. The patient, engaged as usual, possibly in cheerful conversation or in laughing, suddenly feels a stab of pain dart through the affected part as though thrust with a knife. From this time hours or days of agonizing torture may continue with more or less remission, or with entire intermissions. Again, the pain is first manifested as a dull ache, becoming more and more acute until the height of agony is reached. The pain is described as cutting, darting, boring, or burning, by different individuals, and all grades in the impetuosity of the attack are experienced, from the

onset of dull pain, rapidly increasing, to the instantaneous flash of agony.

The general health during the intermissions may suffer little, but the initial attack of neuralgia is usually a sequence of general debility, and in many instances this debility continues during the whole history of the disease. While some sufferers from this complaint are ruddy and apparently in robust health, others are exceedingly anæmic and feeble to an alarming degree.

The presence of painful points during the intermissions of paroxysms is not uniform but frequent. These painful points may be along the course of the nerves most affected or not.

Females subject to chronic neuralgia, and who suffer from anæmia and debility, almost always experience these *points douloureux*, but they are in no sense peculiar to neuralgia. Indeed, they are more generally associated with the more common forms of headache already described. The points most generally painful are: 1. At the spinous process of the first or second vertebra, or over the tendon of the trapezius, on a plane with the upper vertebræ. 2. Over the spinous process of the seventh cervical vertebra; this is by far the most frequently painful point in these cases, and it is very often associated with pain at the lower angles of the scapulæ. Although not an invariable rule, it may generally be assumed that, if the point over the last cervical vertebra is painful, pain will also be found at the lower scapular angles. 3. A point midway between these last-named positions.

4. At the junction of the lower lumbar vertebra with the sacrum. Other points less frequent are at the turn of the shoulder, and a point below the middle of the clavicle. These points have been referred to in connection with headaches, and they seem to indicate a weakened and disturbed state of the nervous system. They are often found in cases of long-standing chorea and in epilepsy, and are peculiarly characteristic of the conditions known as spinal irritation and neurasthenia. They are sometimes found in men, but much less frequently than in women. The pain is not imaginary, as some believe, but is often a source of suffering even from the pressure of clothing.

Intimately associated with neuralgia are certain disturbances of nutrition, as shown in the eruption of herpes; and of motion, as illustrated in the twitchings of tic, but more marked convulsions are not uncommon, and paralyses are sometimes observed.

Vaso-motor and even inflammatory symptoms are among the less common phenomena.

Irradiation of pain to nerves of distant parts is one of the interesting characteristic symptoms of neuralgia, as it has an important bearing upon the reflex nature of all the phenomena of the complaint.

Some cases of neuralgia run their course quickly, a single, or, at most, a very few attacks making up the history of the complaint so far as this peculiar form of neuroses is concerned. Such cases recover spontaneously, or under the influence of remedies real or supposed. Other cases are most chronic, continuing during many months or years, and, if cured, are fre-

quently replaced by other nervous affections. Still others continue during the life of the patient.

The characteristic group of symptoms, therefore, which represent neuralgia may be briefly summed up as follows: Pains mostly confined to the course or distribution of a single nerve, most frequently of one side, and of unusual violence.

The pain is intermitting, or, at least, usually remitting, rarely constant. Certain points in the course of the affected nerve are generally painful on pressure, and associated with the affection are often found painful points not necessarily in the affected nerves, but in certain localities somewhat uniformly.

The pain is also frequently associated with certain motor, trophic, and sensory phenomena.

While inflammatory conditions may occasionally coexist, inflammation of the tissues involved in the suffering is not usual or in any way characteristic.

Valleix has described the superficial and visceral groups of neuralgias, and has minutely described the affection in each specified locality.

It is not within the scope of this essay to describe these various forms of neuralgia, of which it may be said that they are substantially alike, and are governed by almost identical influences. They are all painful, all have the intermitting or remitting character; in each variety painful points may, in a certain proportion of cases, be found in the course of the affected nerve or elsewhere, and in each anæsthesia of the skin is sometimes found.

It is important to note that these various forms

are more or less interchangeable, in some instances more so than in others. They are also interchangeable with other neuroses.

Many persons who, during several years, suffer from *migraine*, are afterward subject to facial or other forms of neuralgia.

The forms of neuralgia are often spoken of as "protean," whereas they are comparatively uniform in character, differing rather in respect to the part affected and, as above stated, quite interchangeable.

Including in this discussion only the forms of neuralgia which may be called idiopathic, not depending upon trauma, pressure from growths, or other exceptional causes, it can not be said that there are any pathological manifestations.

"Neuralgia possesses no pathology, if by that word we intend to signify the knowledge of definite anatomical changes always associated with the disease, in a manner that we can exhibit or exactly describe," says Anstie.*

"Neuralgia," says Erb, "must, in the present state of our knowledge, be regarded as a symptom." †

Neuralgia is common to all classes of society, but is more prevalent in the cultured classes than in others.

A great variety of circumstances may act as immediate causes, among which impoverished circulation, draughts of cold, or excessive physical exertion, are prominent. These and other immediate causes may be

* Anstie on "Neuralgia," etc., D. Appleton & Co., New York, p. 140.

† Erb, "Diseases of Peripheral and Spinal Nerves," "Cyclopædia of Practical Medicine," vol. xl, p. 21.

classified as causes which reduce the total amount of nervous energy, and we are to inquire why such agencies which call perhaps for only moderate expenditure of nervous energy should in certain individuals induce such serious disturbances while in others they produce no appreciable effect?

The answer to this question will be found in the fact that, in those predisposed to nervous affections, there is a constant drain upon the nervous force which exhausts the surplus energy to such an extent that a demand for even a little more is excessive.

Let us suppose the neuralgic patient to be subject to insufficiency of the internal recti muscles, and to be occupied principally in work requiring the use of the eyes at reading-distance. There is an unusual demand upon the nervous supply required to stimulate the muscles of adduction to perform their excessive task. This may cause no local suffering, but certainly reduces the standard of nervous energy. Such a one may be able to generate the full amount of force necessary for the performance of all the ordinary functions and a surplus beyond; but the waste that occurs in the performance of a single function exhausts the surplus, and possibly leaves scarcely enough for the ordinary consumption.

If, now, such person is called upon for some unusual duty, such as attendance upon a sick friend, or is subject to unusual emotional shock, the effect of exhaustion of nervous energy is at once manifest, and an attack of neuralgia, headache, or other nervous disturbance is the result.

The effect of cold is to cause a loss of the little reserve nervous energy which such a person may possess, and also if the effect of cold is upon a single part of the body to cause a demand for a readjustment of the disturbed balance of nervous energy.

Such a waste of nervous energy as we have supposed is a sufficient cause of the anæmia which is supposed to act as an inducement to neuralgia, and again with reduced nervous energy there may be disturbance or delay in the process of digestion or of assimilation.

Indigestion and anæmia are regarded as prolific causes of nervous troubles, but they are themselves symptoms and generally manifestations of the same irritation from which the other symptoms arise.

Let us still suppose our case of insufficiency of the internal recti in which the reserve energy is unduly expended. If such a person indulges in the use of certain classes of food or too much food, there is at once an increased demand for nervous force with which to carry on the now unusually difficult function of digestion. Unless this is furnished, there is distress in the hypogastric region ; but if it is furnished, other disturbances arise, and headache, neuralgia, or even epilepsy occur.

Nerve-wounds, foreign bodies or tumors pressing in the course of a nerve, or other mechanical sources of irritation, may act as original and independent sources of disturbance, or they may unite their influence with a more permanent one.

Anstie* mentions as "one of the most powerful

* "Neuralgia," 1872, p. 169.

sources of peripheral irritation tending to set up neuralgia" the "functional abuse of the eyes." "This," he says, "is one of the very few peripheral influences which occasionally we see producing neuralgia by hereditary predisposition."

The learned writer and acute observer makes little practical account of what he evidently regards as among causes "altogether accidental and factitious."

If we inquire to what extent the natural or acquired difficulties in performing the visual act influence the disposition to neuralgia, we shall find it very great.

Eight hundred and fifty cases in private practice have been examined with reference to the ocular conditions, a large proportion of which have been under observation a sufficient time to enable the writer to judge of the result of treatment in this direction.

Without attempting to make an analysis of the result in all these cases, one hundred consecutive cases are selected, as in the class of cephalalgia, as fairly representative of the whole number.

It is proper to add that these were all typical and chronic cases of several years' duration. Nearly all were people of ample means, who had spared no expense in their endeavors to free themselves from their malady. Nearly all had tried the virtues of drugs, baths, and electricity, while a large proportion had spent much time in foreign travel and in seeking for aid at celebrated spas.

Temporary relief had generally been found from some of these means, but the speedy return of the

complaint after discontinuing medical treatment, or after returning from a delightful journey amid new and interesting scenes, had demonstrated clearly that the relief had not been gained by the removal of the radical cause of the evil.

The one hundred cases selected were examined between the dates May 1, 1881, and August 30, 1882. Of the number, twelve were not subject to important ocular defects or were not seen after the first examination, and may be rejected from this present inquiry. Three placed themselves under treatment but soon discontinued without accepting the advice rendered in their cases.

Eighty-five were treated for the relief of unfavorable ocular conditions with greater or less success in the correction of these anomalies, and with the following results relating to the neuralgic affection:

Of the eighty-five cases, seventy-one were permanently relieved of neuralgia. In ten cases the condition was materially improved, but entire relief was not obtained, while in four cases no relief was gained.

There were, then,

Permanently relieved.....	83·53	per cent.
Materially improved.....	11·76	"
Not relieved.....	4·71	"
	100	

It may be of interest to study the condition of some of those where no relief or where only some improvement was obtained; and an example of each is given.

Mrs. P., aged forty-nine. For twenty years sub-

ject to intense neuralgia, mostly tri-facial. Has frequent fainting-turns, and is in many respects out of health.

Right eye compound myopic astigmatism, corrected by a glass, spherical 2·25 D, with cylindrical 1 D, axis 180°.

Left eye hypermetropic, corrected by spherical +1·25 D.

There is homonymous and vertical diplopia which a prism of 8° with its base out, and another of 2° with its base down, corrects, at a distance of twenty feet, uniting the images.

With a full understanding on the part of the patient that an attempt to produce perfect and easy binocular vision was well-nigh a hopeless task, she determined to make the attempt as a last resort. Glasses were prescribed, and the muscular irregularities so far corrected as to permit binocular vision, but the vast difference in the refractive states of the two eyes rendered the attempt to produce perfectly united action too difficult. Marked temporary improvement in the patient's condition followed the first relief to the diplopia, but the unpleasant symptoms returned after about two months.

Every oculist will recognize the difficulty in attempting to induce any harmonious action between so differently constituted organs, and, assuming that the neuralgia was the outcome of the ocular errors, the attempt could only be regarded in the light of an experiment.

Would it not in such a case be eminently conserv-

ative to remove one of these offending organs rather than to permit all this suffering to continue indefinitely?

The next case shows how the neuralgic habit may be in some measure modified, while some of the important ocular defects on which the neuralgia is supposed to depend may continue:

Mrs. H., aged forty-nine. Subject during the past nine years to neuralgia. Pains located along various nerves. Sometimes manifesting themselves as sciatica, at others as cervico-brachial, and at others as still different forms of neuralgia.

She has astigmatism 1·25 D, with insufficiency of the external recti muscles, and is accustomed to see double very often. There is well-marked mydriasis of the left eye, a condition which has existed for one or two years.

The astigmatism was relieved by cylindrical glasses, and their use was followed by a very marked improvement in the patient's condition. The paresis of the accommodative muscle, however, remains as a permanent and irritating factor for which there is no remedy.

Hence, while a certain amount of relief has been secured, complete recovery is scarcely to be hoped for.

Turning, now, to the more successful class of cases, it will be seen that various conditions which are calculated to create difficulties or perplexities in the use of the eyes are in each of them sufficient to induce the phenomena of neuralgia in different parts of the body.

The first instance which will be presented illustrates the influence of enfeebled accommodation in contributing to the production of neuralgia:

Mrs. S., after the birth of a child, in 1871, suffered extreme torture from crural neuralgia. This, after a few months, gave place to neuralgia of the fifth nerve, while many manifestations of enfeebled health, which had accompanied the first form of the trouble, continued with the other. Among these, anæmia, palpitation of the heart, and dyspepsia were prominent. She continued to suffer from these troubles with slight intermissions, never knowing a month of freedom from severe attacks, until, in the summer of 1874, she was apparently reduced to the last extremity. Notwithstanding all that could be done by a change of residence to a delightful home in the country, where every advantage of excellent air, most careful nursing, and distinguished medical attendance, combined to offer every hope of relief, she grew steadily worse. Her face was colorless, and she was greatly emaciated, the heart's action was extremely irregular, her strength was too much reduced to enable her to walk, and her sufferings from pain were of the most intolerable kind. In this deplorable and almost hopeless state she was removed to her home in the city. One night, while in extreme agony, a small quantity of a preparation of extract of Calabar bean was placed on the conjunctivæ of the eyes as a forlorn experiment. The intense pain was for a moment increased to exquisite torture, when it

suddenly ceased, and the lady fell into a quiet slumber. The relief so happily discovered was followed up whenever the pain returned, for a few days, after which there was no longer occasion for its use, except quite rarely. Strength and color quickly followed, and health was rapidly restored.

In this lady's case there was in one eye emmetropia, while in the other there was myopic astigmatism 0·5 D. This slight difference in the refractive state of the eyes doubtless acted as a perplexing cause to the muscles of accommodation until a state of extreme irritability had arisen.

Recognizing the permanent nature of the refractive states and the liability of a return of her malady, especially as a signal to any unusual cause of exhaustion, she has, during the nine years which have elapsed since the first use of the Calabar extract always kept it within easy access, and, when warned of any return of her trouble, she resorts to an application of a minute quantity of the stimulant to the eyes, with the effect of almost instantaneous relief. By this means she has maintained a state of good health, and has not suffered more than a premonition of neuralgia at any time.

The following case not only shows that ocular defects act as irritating causes to distant as well as proximate nerves, but illustrates the effects of a second of the perplexing conditions in ocular adjustments:

Mrs. F. H. D., aged thirty-six. Has been for many years a victim of intercostal neuralgia. Has

not known an intermission of a month in several years. During the past few months attacks have occurred pretty regularly on alternate days. Her physician resorts to hypodermic injections of morphine, often repeating the injection several times during the same night.

The eyes were examined August 25, 1882, and she was found to have myopia, right 1·50 D, left 1·25 D, with insufficient power of adduction. Glasses for the correction of the myopia were adopted, and the eyes exercised daily until the adducting power was fully established.

Her last attack of neuralgia occurred three weeks after the first effort was made to correct the ocular defects, and during the intervening time of more than a year, she has enjoyed complete immunity from pain and perfect health in all respects.

Insufficiency of the external recti muscles, causing a constant demand for exertion to maintain parallel visual lines when looking at a distance, or perplexity in preventing too strong convergence when the eyes are accommodated for near points, is a third and very frequent cause of neuralgia.

Miss G. M., aged twenty-three, has been during two years a sufferer from facial neuralgia. The focus of pain at the beginning of the attack is at the side of the nose. From this point the pain extends to the face and temple of the same side. She has also severe dorsal neuralgia, and much pain at the lower angles of the scapulæ. During the past six months has suffered from inability to

use the left arm. From the shoulder downward there is marked loss of power, demanding a very pronounced effort to move it. The leg of the same side suffers similarly, and she walks with a very noticeably halting gait. She is also quite dyspeptic.

She has compound myopic astigmatism, and says that she has double vision when fatigued. There is insufficiency of the external recti muscles of 4° at twenty feet.

The myopic astigmatism was corrected by glasses March 30, 1882. The neuralgic attacks were modified but not cured, and on the 4th of June, 1882, tenotomy of the internal rectus of the left eye was made. The neuralgic symptoms disappeared at once, the limbs regained their usual elasticity, and the dyspepsia gave her no further trouble.

October 4, 1883, after more than a year had elapsed, she called, saying that she had been entirely well since the tenotomy, but that within a few days there had been slight returns of pain, but of only sufficient consequence to cause her to inquire into the condition of the eyes.

All modern writers on neuralgia agree in regarding it as an hereditary neurosis. The part played by the hereditary tendency has been very carefully observed in respect to its various manifestations, as exhibited in different individuals of families in which the complaint has been found.

These observations have resulted in showing that in families in which neuralgia exists there is fre-

quently not only a tendency in the blood relations of the patient to neuralgic affections, but to a large class of affections, including chorea, insanity, epilepsy, and phthisis.

The nature of the tendency has remained a mystery, the question of direct transmission of a special form of disease being encountered by the fact that it frequently appears as a sequence of some other form of neurosis.

There are many other reasons for believing that neither neuralgia, epilepsy, nor the other neuroses are directly transmitted as diseases, and it is believed that the evidence about to be brought will remove all doubt upon this subject.

After comparisons of the family history and physical conditions in many hundreds of instances of neuroses, the author ventures the following propositions:

1. *Hereditary neuroses, such as epilepsy, migraine, neuralgia, chorea, and insanity, and the same principle may be stated to hold in respect to phthisis, are not transmitted from parent to child directly.*

2. *Such neuroses are the manifestations of transmitted physical peculiarities which render difficult the performance of certain important functions.*

3. *That of the hereditary physical defects which thus tend to develop neuroses, anomalous conditions of the eyes are among the most frequent and important.*

Taking in my hand at a venture a book of records of cases, I find that it commences January 1, 1878.

Selecting, now, in the order in which they occur, ten consecutive cases of neuralgia in which the family history has been written, we find striking evidence in support of these propositions. It should be said in passing that in the pressure of work the family histories of many cases of these neurotics have not been written, hence these cases are not literally consecutive cases of neuralgia, but consecutive cases of that disease, in which the family history has been recorded:

Table showing the neuralgic and ocular conditions in ten successive cases of important neuralgic affections, with the physical condition or immediate cause of death among immediate relations, with the result of treatment directed to refractive and muscular conditions of the eyes.

CASE.	Form and duration of neuralgia.	Ocular conditions.	Physical condition or immediate cause of death of parents, brothers, and sisters.	Results of treatment directed to ocular conditions.
I. Lady, aged 35.	Supra-orbital, alternating with migraine; duration, 2 years.	H $\frac{1}{17}$, insuf. interni.	Father (and his sister) died insane; mother has chronic neuralgia; sister a nervous invalid.	Permanent relief.
II. Lady, aged 28.	Facial neuralgia, insomnia; duration, many years.	H $\frac{1}{17}$.	Father and mother died of acute diseases; one sister has chronic neuralgia; of a brother and sister no account is given.	Not known.
III. Lady, aged 46.	Facial and cervico-brachial; duration, 15 years.	H $\frac{1}{15}$ + Ah $\frac{1}{24}$, insuf. externi.	Father died of phthisis; mother had chronic neuralgia; one brother chronic neuralgia; one has epileptoid vertigo; one sister strabismus.	Permanent relief.
IV. Lady, aged 40.	Facial; duration, 4 years.	Ahm $\frac{1}{16}$.	Father and mother neuralgic; no brothers or sisters.	Permanent relief.
V. Gentleman, aged 65.	Cervico-brachial, intercostal, etc.; duration, 20 years.	As $\frac{1}{30}$, insuf. externi.	Father asthmatic; mother was subject to migraine; a brother died of cerebral disease; another brother and four sisters subject to migraine. One child of the patient died in an insane asylum, and three other children died of nervous diseases.	Permanent relief.

Table showing neuralgic and ocular conditions (continued).

CASE.	Form and duration of neuralgia.	Ocular conditions.	Physical condition or immediate cause of death of parents, brothers, and sisters.	Results of treatment directed to ocular conditions.
VI. Lady, aged 35.	Cervico-brachial, etc.; duration, 2 years.	M $\frac{1}{6}$ Am $\frac{1}{15}$, insuf. interni and vertical insuf.	Mother and two sisters have nervous complaints; all astigmatic; father well.	Permanent relief.
VII. Gentleman, aged 38.	Facial neuralgia and cephalalgia; duration, many years.	Ahm $\frac{1}{20}$.	Father subject to migraine and asthma; mother has disease of the heart; a brother has chronic headaches; another suffers from dyspepsia; three sisters are nervous invalids.	Permanent relief.
VIII. Lady, aged 56.	Supra-orbital neuralgia; duration, 10 years.	H $\frac{1}{24}$.	Father epileptic; mother died of Bright's disease; a sister died of heart-disease; another sister has chronic neuralgia.	Permanent relief.
IX. Gentleman, aged 55.	Dorso-intercostal; duration, many years.	H $\frac{1}{14}$.	Father blind and a hard drinker; mother always subject to migraine; a sister subject to spinal irritation.	Permanent relief.
X. Lady, aged 24.	Lumbo-dorsal neuralgia; duration, 5 years.	H $\frac{1}{12}$, insuf. interni.	Mother always subject to migraine; father died of Bright's disease; three sisters have important nervous disorders.	Permanent relief.

Three important factors characterize this list of cases:

1. In all, the hereditary tendency is clearly shown.

2. All have marked refractive and muscular anomalies, which are physical features, distinctly hereditary.

3. The uniform relief from the irritation caused by these physical peculiarities proves that the hereditary tendency to nervous troubles and the hereditary physical peculiarities were in these cases one and the same.

It is distinctly stated that the ten consecutive cases above quoted do not materially differ in their signifi-

cance from a like number of cases taken incidentally from other parts of the records, although in a like number the same proportion of marked refractive lesions might not always prevail. Should a greater number of consecutive instances be selected in any part of the whole list, the teaching would be practically the same.

The unmistakable inference to be drawn, therefore, from the study of a great many cases, is that the hereditary tendency to neuralgia is quite commonly found in the physical construction of the eye or of its appendages, and that when it is found elsewhere it may be regarded as in a degree exceptional.

In assuming this inference to be correct, it is not necessary to ignore known facts concerning the disease, although some ancient prejudices may possibly obtrude themselves in opposition to it.

This inference is entirely consistent with the facts that certain influences act as immediate agents in inducing the disease, and that in a certain proportion of cases other permanent conditions may be quite as active as causative instrumentalities.

It is also consistent with the fact that neuralgia is a complaint which most frequently makes its appearance, not in childhood, when the tissues are most pliant, and when the effects of refractive anomalies and muscular insufficiencies can be most easily overcome, but at an age when efforts to overcome these difficulties increase, and when the faculty of close and critical vision is brought most prominently into use.

This inference is also notably in harmony with the

fact that neuralgia is so frequently interchangeable with migraine, epilepsy, and insanity; for we have already seen that visual defects are most important factors in the production of migraine, and we shall find that it is scarcely less so in the causation of other neuroses.

It is manifestly fallacious to presume that epilepsy and neuralgia are convertible diseases, and that one can be directly the originator of the other by inheritance or by any necessary sequence in the same individual. On the other hand, it is quite reasonable to suppose that a common cause acting upon different individuals, or upon the same individual at different times, may give rise to such irritation as shall be manifested as neuralgia, epilepsy, or insanity, depending upon the resisting strength of the individual, upon his environment, and other circumstances.

By accepting such a view, a great element in the doctrine of heredity may be removed from the realm of mystery, and placed in the domain of legitimate knowledge.

In order that the inference here asserted may not be misunderstood, it may be repeated that it is not claimed that ocular defects are the only hereditary features which may give rise to neuralgia, but that they are pre-eminently important.

Incidental causes may become more or less permanent according to their nature, and induce neuralgia or other neuroses during their continuance.

A gentlemen who had suffered most violent facial neuralgia for many months, forcing him to relinquish

his business and to seek in vain relief at a celebrated spa, was found to have a mass of hardened cerumen in the ear. The removal of this mass was followed by instant and permanent relief. Many instances of which this is a fair illustration might be mentioned, but they constitute no such general class that the nature of the cause may be inferred from the presence of the disease. They are accidental, and should always be sought for.

Such instances might be classified with those arising from pressure from tumors or growths and from traumatic causes.

SPINAL IRRITATION AND NEURASTHENIA.

Closely related to neuralgia are the conditions commonly known as spinal irritation and neurasthenia. They are characterized by general loss of nervous energy and by local symptoms more or less complex; certain symptoms, however, prevailing more in one than in the other form of nervous disturbance.

In females the neuralgoid pains at various points at the neck, back, and loins are wont to assume much prominence; great weariness, reduced power of endurance, disinclination or even disability to walk or to perform any physical exertion, increased mental irritability and disturbance of sensations, all go to constitute a group of symptoms quite commonly known as "spinal irritation"; while in men there is less of the neuralgic element, with more dull pain in the extremities, or general sense of exhaustion, inability to continue at office-work where writing or attention to ac-

counts is required, and frequently a general sense of illness which prevents the patient from following his usual avocation or even confines him to his bed. These cases have been known as "neurasthenia."

It will be seen that females, in whom there are usually the most acute sensibilities, suffer more from neuralgic symptoms, while men are more affected by dull pains and hypochondria. Unusually sensitive men exhibit as the result of this nervous exhaustion the group of symptoms known as spinal irritation, while women of less than ordinary susceptibility to acute impressions have neurasthenia.

Allied to these two forms of nervous troubles, and to a certain extent including them, are the affections graphically described by Marshall Hall as "mimoses." These are characterized by weakness, tremor, headache, vertigo, flutterings, weariness, pain, and tenderness in various places, constipation and hysteric affections.

Attending these symptoms are also frequently observed loss of flesh, decay of the teeth, chronic pharyngeal affections, and a morbid state of the gums.

The patient has cold feet, and "he is unaccountably feeble and weary, and suffers from a sense of aching after slight exertion." *

The name "spinal irritation" implies a pathological condition not demonstrated; and the division of these varieties of nervous exhaustion into distinct specific forms is at least doubtful. The name applied by Marshall Hall is as inclusive and as fully descriptive as

* Marshall Hall, "Mimoses," 1823, p. 22.

either, and does not imply any theory of the nature of the disease.

It is not, however, the aim of this paper to discuss the classification of diseases, and it is necessary only in this connection to notice the fact that the forms of troubles known under the names mimoses, spinal irritation, and neurasthenia are simply variations in the expression of a chronic waste of reserve nervous energy—the depleted force being in these instances indicated more especially as weakness, illy defined pains, and general nervousness, than in specific explosions of pain. Here, again, we see the result of a permanent neuropathic predisposition or cause of loss of nervous vigor, and here we shall also find that the loss is very often to be explained by the unusual amount of force expended in performing the visual function.

A few examples will show this fact more clearly than much argument:

Mr. E. N., aged forty. First examined March 10, 1881. Patient is a tall, well-built man, quite thin and sallow, but showing no indication of unsoundness of internal organs, although he has within a week been assured by a distinguished practitioner that he has Bright's disease of the kidneys. Examination of the urine does not confirm this diagnosis. Eight years ago he began to experience much weakness and general sense of *malaise*. Headache commenced about the same time, and has been an important symptom during the eight years of his disability. The headache is not

constant, but occurs after efforts at reading and writing; it affects the top of the head mostly. Has dull backache, and a feeling of stiffness on bending. Lower part of the back habitually subject to dull pain. He is quite weak; walks with much difficulty, but can stand and walk with eyes closed. There is a general sense of muscular weakness and dull pain in the legs. Has palpitation of heart after walking or going up-stairs. Sleeps poorly. Appetite variable. Has very frequent calls to evacuate the bladder.

He has been obliged to surrender his business, and has for some years devoted himself to efforts to restore his health. To this end he has several times traversed the ocean, twice crossing and returning in a sailing-vessel. While at sea, he is free from pain in the head and back, but gains little in strength. He has used tonics, electricity, baths, and a great variety of supposed remedies, but finds nothing but a sea-voyage of especial service, and the symptoms of debility return rapidly after the voyage is over.

He was found to have insufficiency of the external recti muscles, and partial tenotomy of one, and soon afterward of the other internal rectus was made. Relief, very marked and permanent, quickly followed. The patient returned to his duties, as an officer of a large association, very soon after the first operation, and has continued in excellent health to the present time; has gained largely in flesh, is able to walk as well as others, and has no headaches or pain in his back or legs.

The following case of typical neurasthenia is equally typical of the cases described by Marshall Hall under the name mimosis:

Miss P., aged forty. Was seen by request of her attending physician, Dr. Gault, in August, 1882. She was found in her bed, to which she had been confined for the most part of the time during the past three years. The following history was obtained: The patient had not been well for several years before resorting to her bed, but being a person of much strength of character had exerted herself to continue on her feet as long as possible. There had been a great sense of weakness and inability to use her limbs, and a sense of fatigue and dull pain in the lower extremities. There was also a dull ache extending from the neck to the lower part of the spine. She had dull pain in the chest and right side and below the scapulæ. With these a dull, generally pervading headache was a very common accompaniment.

In April, 1879, she resorted to her bed, which she kept during more than three years, with rare and short intervals, when she was able to leave it for a few days. Such intervals of improvement were almost always followed by greater prostration than had existed for some time before. Especially was this the case if any attempt to walk or engage in any occupation was made.

During all this time she has been dyspeptic, the stomach refusing, much of the time, to retain food, and she was greatly troubled with constipation, subject

to cold extremities, palpitation, and general sense of extreme weariness; the body was often bathed in cold, oily perspiration. The nervous irritability was so great at times that she was unable to listen to any conversation by her attendants or others. She became extremely reduced in flesh and despondent in spirits.

It was in this condition that she was found. A significant circumstance observed during the consultation was the fact that during the conversation she lay with the forefinger of the left hand closing the lids of the eye of that side.

A subsequent examination of the eyes showed hypermetropic astigmatism 1 D, with insufficiency of the external recti muscles.

August 30th, partial tenotomy of left internal rectus was made. September 3d she walked upon the street nearly the distance of a block. September 26th, her walks had been extended to a mile and a half daily. All the symptoms of nervous prostration were greatly relieved, but she still spent a portion of the day in bed.

As there was still slight insufficiency of the external recti muscles, tenotomy was very carefully repeated, this time upon the right eye.

From this time the patient continued to improve in strength and endurance. No relapse has at any time occurred, and she is no longer dyspeptic nor constipated, and often walks two or three miles at a time.

More than two scores of cases of as well-marked nervous weakness as either of the above have been under observation and treatment for ocular difficulties, with equally happy results.

Such nervous exhaustion, when it is the result only of overwork, speedily disappears when the presence of excessive demands upon the nervous energies is taken off. If such exhaustion continues as a chronic ailment, there is evidence that there is a perpetuating cause which should be sought for and removed.

These conditions of nervous weakness are, in females, often attended by relaxation of some of the pelvic muscles and ligaments; uterine deviations result, and perhaps act as secondary causes. These secondary causes, themselves symptoms, are frequently treated during months and years with results too well known to the medical profession.

CHOREA.

We enter upon a brief examination of an extremely interesting subject, one which might well demand a most careful and extended review. It is proposed, however, in this place, only to call attention to the bearing of some of the most characteristic features of the disease upon the subject of its etiology and treatment.

Notwithstanding the assertion of many learned writers that, as *all* cases of chorea are chronic, there can properly be no distinction of acute and chronic forms, it is well known that while recovery takes place in the great majority of cases of chorea in from two to four months, there remains a certain proportion of cases in which the complaint, resisting all medical treatment, continues many years or a lifetime.

The distinction made by Sée of common and chronic chorea, would therefore seem a practical one.

A fact, now recognized by those most familiar with the common form of chorea, is that under almost all circumstances recovery takes place within a few weeks after the onset. Hence, a great variety of remedies have been supposed to be nearly or quite specific; and cases are reported cured by cathartics, by bleedings, by vermifuges, and cold shower-baths, as well as by vegetable tonics, iron, strychnia, arsenic, chloral, and almost numberless so-called remedies.

It is an interesting fact that, in defiance of such means as are mentioned in the first part of the foregoing list, recovery takes place almost as soon as under the more rational tonic treatment.

In the chronic form, however, there are no specifics; neither cathartics nor tonics do much if any good, and the patient is doomed to years of suffering and perhaps to death, for death not infrequently comes to the relief of these unfortunate sufferers, while the physician consoles himself with the unfounded dictum that the disease, being based upon chronic lesions of the brain or spinal chord, is therefore incurable.

That anatomical lesions of the brain or of the cord are sometimes coincident with chronic chorea it is true, but that there is necessary or causative relation between the two conditions has not been shown. Indeed, it is much more probable that the anatomical lesions of the brain and cord are among the results of chorea or of the irritation causing it, and that they

are not in in any respect the original sources of irritation.

In considering the interesting fact that so many cases of "chorée vulgaire" recover under so many radically different methods of treatment, the age of the patients, and the circumstances attendant upon the period of life at which the great majority of cases occur, must be regarded as an important factor in explanation of the circumstance.

Dr. P. H. Pye-Smith found that of 136 choreic patients at Grey's Hospital,* 106 were between the ages of six and fifteen, and 62 of these were between the ages of six and ten. In other words, nearly half were at the age when children enter schools, and nearly all were children of school age.

Researches of the author of this essay prove that the majority of cases of chorea occur among children who are hypermetropic. If we consider that the strain upon the muscle of accommodation in these hypermetropic children is, during the first years of school-life, an unusual one, and that the attending confinement and possibly impure air of schools may aggravate the effect of the excessive demand upon the accommodation in delicate children, it will not be difficult to see that great nervous disturbance may result.

Now, upon the advent of decided symptoms of chorea, the child is, in the great majority of instances, *at once removed from school.* The strain upon the overtaxed accommodation is relieved, and in the space

* "Grey's Hospital Reports," third series, xix, p. 341.

of a few weeks, as soon as time has been allowed for the overtaxed muscle to regain its tone, the child recovers from chorea, in defiance of medicines or possibly assisted by them.

An important symptom of chorea may also be directly explained on this hypothesis. It is well known that widely dilated pupils, reacting feebly in response to the influence of light, constitute a very characteristic feature of this complaint, and it has also frequently been observed that on the termination of chorea the dilatation of the pupils disappears. Dilatation of the pupils is not always, but, as a rule, associated with enfeebled accommodation, and may be regarded as indicating weakness of the ciliary muscle in proportion to the degree of mydriasis. An example is found in paralysis of the third nerve, when the pupil is widely dilated and accommodation nearly or quite suspended.

Returning to the condition of the pupil in these choreic children, a great proportion of them are hypermetropic. They have not been accustomed to the continued act of accommodation, and when sent to school or put to any other close work where a very marked and continued effort to maintain accommodation is required, the ciliary muscle experiences fatigue and finally exhaustion, its action is considerably enfeebled, and with it the action of the sphincter pupillæ. The widely dilated pupil is the signal which tired Nature gives as a warning to discontinue overwork of the exhausted muscles. If the signal passes unheeded, the whole nervous system surrenders. When the

child is withdrawn from school, or other employments which require the use of the eyes at close range (for many of these children are from among the poor, who demand a certain amount of labor even from the very young), the wearied muscle gradually regains its contractile power, and the pupil returns to its normal state.

Hence we may justly reverse the statement made above, that the dilatation of the pupil disappears on the termination of chorea, and say that with the proper contractile power of the ciliary muscles nervous quiet is restored.

In reply to this line of argument may be adduced the fact that many children and even adults with dilated pupils do not have chorea. To which, again, it may be replied that not all similar causes, acting upon different individuals, produce like effects.

It has been stated that observations have shown that the majority of cases of chorea occur among hypermetropic children. Of 118 cases examined in private practice—

Simple hypermetropia existed in..... 78
Hypermetropic astigmatism existed in.... 13
Mixed astigmatism in..... 5
Myopia, unequal in the two eyes, in..... 6
Myopic astigmatism in..... 11

Associated with these conditions in a considerable number of the above cases, more or less muscular disability was found.

Insufficiency of the lateral recti muscles, with no marked degree of refractive error, existed in five.

It will be seen, therefore, that if ocular irritation is admitted to be a factor in chorea, hypermetropia must play an important *rôle*. It can be easily understood, then, why chorea, in the ordinary cases, ceases, as does asthenopia, but somewhat less promptly, upon discontinuance of the use of the eyes for close work.

Hence, also, it will be seen that he who treats a few cases of chorea in a special way is likely, if the child is in each instance withdrawn from school, to witness a cure; and thus he comes to regard the agent employed as the curative means, whereas in fact the rest was the actual curative agency.

Manifestly statements of cure based upon the class of cases which may be called acute, must be comparatively of little weight, as they may bear no relation to the influence of the supposed remedy.

Nevertheless, the experience of many of the best observers goes to prove that, on the whole, cases recover more quickly under the influence of tonic remedies than otherwise. Notwithstanding the somewhat definite termination of chorea in recovery, it is true that in after-life a great many of those who have been victims of the complaint suffer from some other form of neurosis. It would be impossible to say to what extent this statement holds without tracing the history of a considerable number of cases through several years. The statement is based not only upon the observations of many writers, but upon a considerable number made by the writer, in which he has learned that patients, who in adult life suffered from epilepsy, neuralgia, and headache, were in childhood subjects of

chorea. And it has also been observed, in several of these cases, that a supposed cure of chorea has been only a change to chronic headache, or other neurosis.

Passing to the less hopeful class of cases, those of the more chronic form, the results of treatment, if favorable, may be regarded as significant. If, after several years of suffering, relief follows uniformly upon the employment of certain remedial measures, and if the disease is not replaced by another, it is quite legitimate to suppose that the remedial measures have been directed to the true cause of the complaint.

After careful study of the cases which have been examined, and treatment of many of them for the removal of ocular anomalies, the author does not hesitate to assert the direct relation between these ocular difficulties and the disease in question.

The study of the cases which are here adduced can not fail to confirm this assertion. These cases are selected as being in all respects representative of the class of chronic cases generally supposed to have their origin in some anatomical lesion of the nervous centers.

They are all typical in respect to the general muscular irregularities, all accompanied by marked mental effects, all exceedingly chronic, and each has received the benefit of continued and able medical attendance.

Mr. E. L. D., aged thirty. First seen July 13, 1882. When about ten years of age began to have chorea. The cause was supposed to be a slight injury to the head received some weeks before the advent of choreic symptoms. The disease has run a pretty uniform course during twenty years.

He now has the characteristic jerkings of the face, legs, and arms; twitchings of the abdominal muscles are among the most constant and unpleasant of the choreic disturbances. He appears languid, and says that he is always tired. He is thin in flesh, draws his legs in walking, sleeps irregularly, has headache much of the time, and for ten years past has experienced all the troublesome symptoms of asthenopia.

His circumstances have been such as to permit him to employ whatever means offered a reasonable hope of relief, but every attempt has met with failure.

I find hypermetropia 1·25 D, with insufficiency of the external recti muscles.

Convex glasses were prescribed for constant use, and on the 24th of July, 1882, tenotomy of the right internal rectus muscle was performed, apparantly restoring the equilibrium of the lateral muscles. A marked improvement in his symptoms commenced at once. Within the next two weeks the choreic symptoms were scarcely noticeable, and he no longer suffered from headache. He was seen a month later, still gaining in flesh, strength, and spirits, and on the 18th of August, 1883, he called, in passing through the city, to report his condition. He seemed in perfect health, had no choreic symptoms, had gained much in weight, and declared that he had no recollection of a year of such complete health as he had enjoyed during that which had just passed.

Miss K., aged nineteen, came in April, 1879, by the

advice of her physician, Dr. L. B. Newton, of North Bennington, Vermont.

Has had chorea nine years. The malady first exhibited itself in twitchings of the eyelids and general restlessness, while attending school. To this condition, twitchings and contortions of the limbs soon succeeded, but she was not removed from school until the symptoms became so violent that she could no longer attend.

To the violent muscular disturbances were added severe and almost constant headache.

Choreic disturbances and headache have continued during the nine years with no important remission. The patient is exceedingly low-spirited and feeble, has the look of utter despondency, is unable to attend to any employment or to amuse herself with books. As she sits, her head is continually drawn by powerful and sudden muscular contractions toward the right shoulder, a movement effected every few seconds, and apparently accompanied by mental and physical suffering. The hands and feet twitch incessantly, and the facial muscles are rarely at rest.

Against this distressing condition of mind and body she has employed such means as able physicians have advised, with entirely negative results.

She was found to have a moderate degree of myopic astigmatism, with insufficiency of the internal recti muscles.

Cylinders for the correction of the astigmatism were prescribed, and a month later tenotomy of one of the

external recti muscles was made. The operation was followed by exercises of the ocular muscles by the aid of prisms for some days until a good degree of flexibility of all the muscles was obtained.

The health of the patient commenced to improve rapidly from the time of the tenotomy, and within a few weeks her health was in all respects restored. She has been seen from time to time during the interval of more than four years, and on all occasions she exhibits physical and mental conditions in most marked contrast to those which formerly existed. Her face has the glow of health. She is well nourished, walks with elastic step, has no headache, and is in the enjoyment of all the hopes and happiness natural to one of her age.

Miss J., aged fourteen. Came with a letter from her physician, Professor A. T. Woodward, March 14, 1883.

> Has had chorea for rather more than a year. Has muscular twitchings in limbs and body, is exceedingly restless, and is in a peculiar and unfortunate mental condition. She is willful and stubborn, morose and unreasonable. She escapes from her attendants when walking, and often hides herself. Her speech is slow, her voice monotonous and dragging. Dementia is the term which most clearly expresses her intellectual state. She is pale, thin, and weak. There is no evidence of disease of the heart or of any internal organ.
>
> Examination of the eyes shows that she has hypermetropic astigmatism ·75 D, and that the ocular muscles have but feeble associating force.

Adducting power at twenty feet, 8° ; abducting, 2°. By exercising the eyes for a few minutes daily with prisms, the adducting power in the course of two months rose to 35°, and the abducting power 8°.

She had, in the mean time, made use of cylindrical glasses for the correction of her astigmatism.

Her health improved in proportion as the flexibility of the ocular muscles increased, and she went away at the end of two months much better in all respects than when she came.

October 20th, after nearly five months, she calls with her mother. She is in perfect physical and mental health. She shows no indication of nervousness, is rosy, and has a bright, intelligent expression ; speaks quickly and without monotony, and is in all respects a healthful, intelligent, and tractable child.

Master I., aged thirteen years. Came attended by his physician, Dr. P. H. Neher, October 30, 1879.

The patient has been the subject of chorea nine years, during which time he has been under the charge of several distinguished physicians, who have treated him by tonic medicines, including preparations of iron and arsenic, strychnine, and other medicines. Electricity and change of climate have also been among the means through which relief has been sought, but not obtained.

His condition at the present time is deplorable, although not worse than usual with him. The muscular contractions are most violent, and extend to all parts of the body. It is with great difficulty that he can sit in a chair, as the body is thrown

about so violently as to dislodge him from his seat. Even while sitting the legs are thrown in all directions, and his head strikes the back of the chair with frequent and energetic thumps.

When walking, the legs become entangled, and the head is thrown backward with the greatest violence. With much difficulty the condition of the eyes was determined.

He was found to have hypermetropic astigmatism and insufficiency of the externi, with insufficient adducting energy, the latter being sufficient only to overcome a prism of 6°.

The astigmatism was corrected by cylindrical glasses, and the adducting power exercised until it was greatly increased.

When, at the end of two weeks, his physician called to see him, he was amazed at the change that had come over the lad. He was now able to walk with regular and even steps, could sit in his chair at ease, and, indeed, appeared well. With some varyings in his condition which could, in all cases, be associated with equally varying conditions of the eye-muscles, he recovered rapidly, and, with the exception of occasional slight twitchings, has remained well during the four years.

Miss M., fifteen years of age, examined November 27, 1881.

Eight years ago had chorea, which has continued to the present time. There are facial contortions, shrugging of the shoulders, and general restlessness. She is well nourished and finely de-

1.

2.

veloped, is intellectually bright, and at times cheerful.

There is a murmur with the first sound of the heart, but no other evidence of organic disease.

During the eight years there have been periods of a few weeks when there has been slight remission of the symptoms, but they have never at any time disappeared. She is better if she avoids books and keeps much in the open air.

She has astigmatism of low grade and insufficiency of the internal recti muscle 6° at twenty feet; 7° at one and a half foot.

Early in February, 1882, tenotomy of one external rectus was made and three weeks later of the other. Improvement in the nervous state followed, and entire recovery within a few months.

During the past two years she has pursued her studies abroad, and I learn from a letter, written within the past month, that she is still quite well.

[The two portraits shown in Plate II are those of an interesting case of chorea which had continued during the lifetime of the patient, a boy of sixteen. The boy was feeble-minded and incapable of learning. His whole body was in perpetual motion. This is well shown in the photograph, taken April 28th, when, notwithstanding the rapidity of modern photography, it was quite too slow to get a clear picture. The shaded borders of the picture show the movements of the head. The boy had hyperopia 2·50 D., and insufficiency of the interni, to the extent of producing, much of the time, homonymous diplopia, which was shown when a

red glass was placed before one of his eyes, the refractive error being first corrected. Tenotomy of the left internus was done, April 28, 1885, and of the right on the 6th of May following.

The change in the boy's condition was marvelous. The two portraits do not exaggerate the improvement, nor do they even adequately represent it. He has had no chorea during the two years which have past. He has attended school, where he has made some progress in his studies, and is in every respect mentally and physically greatly improved.*]

Many cases, of which those already described are fair examples, might be adduced to prove the relations between those long-continued cases of chorea and irritations attributable to the eyes. It is needless, however, to accumulate evidence of this kind beyond what has already been offered.

It can not be doubted that the relief so speedily obtained in these cases not only followed the treatment directed to the eyes, but that this improvement was the legitimate result of such treatment.

If, then, refractive and muscular troubles of the eyes are so generally found associated with chorea, and if cases which may justly be regarded as belonging to the class heretofore regarded as incurable, are able to obtain such speedy and complete relief as is shown in the cases described, may we not conclude that *chorea is emphatically a nervous trouble depending upon ocular conditions?*

* This case, not in the original essay, is introduced here on account of the accompanying portraits of Plate II.

That irritations seated elsewhere may cause the disease, is not to be denied.

Especially may irritations, proceeding from different parts of the body, act as immediate or as complicating causes, but it is probable that cases which occur without any relation to ocular difficulties are rare exceptions to a very general rule.

The indications for the treatment of chorea are evident if the general nature of the cause, as shown, is admitted. Children with the first symptoms of "*chorée vulgaire*" must be at once removed from school, and from all occupations demanding the use of the eyes. General tonic remedies, fresh air, and agreeable surroundings may all prove valuable as auxiliaries in the treatment of these cases. The use of a weak solution of eserine applied to the eyes once or twice a day will often serve as a valuable temporary expedient.

The child should not be returned to school without an examination of the eyes in regard to their refractive and muscular states. In chronic cases the cause should be sought for in the eyes. If not found there, at least a very probable seat of trouble will have been explored.

EPILEPSY.

The course of this discussion now leads us to consider one of the most important as well as one of the most mysterious of all the affections of the nervous system. A disease dreadful in its manifestations, and well-nigh hopeless in its prognosis, nearly always un-

fitting its victims for useful employment or enjoyment during its early periods, it generally robs them of intellect and reason in the end.

Any additional knowledge of this fearful malady must prove a valuable contribution to science, if it can be made available for the relief of any proportion of its victims.

For the purposes of this discussion the form of epilepsy only which does not depend upon visible anatomical lesions is to be considered.

It has, of course, no "pathology," so far as the description of physical alterations of structure are concerned, and it is unnecessary to dwell upon any description of the phenomena of the disease.

Doctrines respecting the etiology of this malady are extremely unsatisfactory, while it is by all conceded that epilepsy may be the sequence of certain immediate causes, such, for instance, as blows, the irritation of dentition, mental emotions, and prolonged and excessive fatigue or anxiety.

It is also very generally supposed that these exciting causes would be ineffective in producing a long series of epileptic seizures were not some predisposing cause present.

Of the nature of such predisposing cause or causes, only a vague kind of knowledge has been possessed.

Heredity has been regarded as the great predisposing cause, but in what manner this hereditary tendency is transmitted there has been no satisfactory explanation. To assert that this disease is hereditary implies little if any practical knowledge of what can

be done for its relief unless we are prepared to determine something of the nature of the inheritance. It may not be out of place to repeat, what has already been stated, that it is scarcely reasonable to suppose that one disease is the direct sequence of another; or that epilepsy is directly inherited from chorea or phthisis. The inheritance, then, is a *tendency* or *predisposition*, and not the disease itself.

Is the tendency, then, a part of the physical conformation inherited by the offspring, or is it some spiritual essence which passes from parent to child?

This latter alternative need not at the present day engage our attention. Diseases are neither entities, which find a lodgment in the systems of certain persons and there work out their malign missions, nor are they spiritual manifestations.*. They are physical irregularities, depending upon physical causes and obeying physical laws.

It is not to be presumed that all the mystery of inheritance in disease will ever be revealed, nor is it at all probable that all the obscurities which surround the subject of epilepsy will ever be lifted away, yet it is possible that sufficient light may penetrate this darkness to enable us to hope for better results from treatment than have heretofore rewarded the efforts of the physician.

If the views of hereditary tendency in nervous dis-

* This view does not imply that toxic agents are not destructive, nor that microscopic organisms may not so multiply in certain parts, or in the whole body, as to generate disease, nor does it ignore many other forms of injurious or destructive agencies.

eases which have already been suggested in discussing the subject of neuralgia, and which will be somewhat further discussed in a section to be devoted to the subject of heredity, are correct, an important element in heredity is to be found in the construction of the eyes and of their surroundings.

However extravagant the view, that an hereditary tendency to nervous diseases may descend with this physical feature, may appear to one who has not fully considered it, it can not in the light of facts be dismissed.

There may, in view of all the knowledge which can at present be brought to bear upon the subject, be different estimates of the frequency and of the importance of this factor in the cause of the neuropathic tendency, but its existence as a factor must be admitted.

Without attempting further discussion of this as a supposed cause, or of other known causes, the practical results of experience in this form of disease will be given.

Examinations of ocular conditions have been made in one hundred and forty cases of epilepsy, eighty-five of which were in private practice. The general result of these examinations has been to reveal the existence, in these cases, of refractive anomalies in a considerably greater proportion than has been found by Cohn in his examinations of the eyes of school-children, or by other observers in similar investigations prosecuted in Germany, Russia, and America.

In one hundred consecutive cases there existed:

Hypermetropia (including hypermetropic astigmatism) in	59
Myopia (including myopic astigmatism) in	23
Emmetropia, or refractive errors less than 1 D	18
	100

In four of the cases in which notable errors of refraction were not observed, atrophy of one of the eyes existed.

In the greatest number of cases examined in private practice very marked insufficiency of the motor muscles of the eyes was found, and it may be here observed that, so far as ocular irritations are concerned in the origin of a tendency to epilepsy, muscular irregularities are doubtless much more efficient than refractive anomalies.

The proportion of refractive errors stated above, would not of itself prove a relation between the state of the eyes and epileptic condition, although the proportion is notably in excess of that found by examinations of those in health. This circumstance, however, taken with that of a state of insufficiency of the ocular muscles existing very generally, renders it probable that the ocular defects may be in relation to the epileptic tendency.

The facts, however, which have already been presented in regard to other nervous affections must have a certain weight in this connection, and must add to the probability of the relations suggested.

If now we add to these evidences, which are in

themselves only important suggestions, the results of treatment based upon the supposition of epileptic influence arising from ocular defects, we shall find it certain that these relations are of the highest importance.

Of the eighty-nine cases examined in private practice, thirty-four only have been treated and observed for any length of time beyond one or two visits.*

Of this number five have withdrawn from treatment before obtaining any relief from important ocular defects, and should not be included in calculating the results of treatment. The remaining twenty-nine cases have been treated only by the removal of ocular defects. Of these twenty-nine cases, fourteen may be considered well; two, who are still under observation, are believed to be permanently relieved; three others, still under treatment, have received such marked relief that it is believed that an entire discontinuance of the malady may be expected. One, who had manifested some improvement, died of accident four months after his first visit. Seven others have received temporary relief, while two have manifested no improvement.

In order that a proper estimate may be made of the value of treatment directed to the eyes in these cases, a considerable number of them will, at the risk of demanding some patience on the part of the reader, be reported at such length as to enable one to determine whether the results have been incidental and facti-

* In the haste of preparing this memoir as originally presented, a few cases of epilepsy were overlooked; hence these numbers do not exactly correspond with those given in the original paper.

tions, or legitimate sequences of scientific treatment directed to the removal of the cause for the disease.

It is proper to add that the question of the influence of drugs in the treatment is eliminated by the fact that in some cases none had been taken for a considerable time before treatment directed to the ocular conditions, and in cases in which they had been used up to the time that the patient came under observation, they have in every instance been at once discontinued.

Mr. W. H. A. came by the advice of his attending physician, Dr. A. T. Woodward. The patient had, during nearly four years, suffered from attacks of epilepsy, occurring about once in two months, but sometimes more frequently. During some months, from September, 1875, to June, 1876, he used, by the advice of his physician, atropine in considerable doses, with the effect of lengthening the intervals between the attacks slightly, but since discontinuing the medicine they have returned with more than usual frequency.

His eyes were examined August 24, 1876, and he was found to have hypermetropia $\frac{1}{24}$. The defect was corrected by glasses, and the attacks ceased until the following year, when, after discontinuing the use of the glasses a month, an attack occurred. The use of glasses was at once resumed, and the patient has continued free from the malady up to the present time.

In the two following cases the irritation unquestionably originated in the ciliary tract, although not from refractive or muscular difficulties, but from the

fact that the ciliary nerves were involved in the cicatricial tissue:

C. D., five years of age, was examined in March, 1878.* He had been subject to very frequent epileptic attacks during more than a year past. Convulsions occurred generally as often as once in two or three days. The child was also suffering from other general diseases, and was feeble and irritable.

The right eye was staphylomatous, protruding so prominently as to prevent closure of the lids. It was learned that in infancy he suffered from ophthalmia neonatorum, and that the staphylomatous condition had been the result of this disease.

The ruined eye was at once removed, and with its removal both the epileptic seizures and the other affections ceased—no attack of epilepsy occurring after the day of the operation.

J. W., aged fifteen, had been subject to epilepsy since he was eleven years of age. When he was ten years old he had had erysipelas of the face and had lost the right eye, which had become atrophied, the cornea and ciliary region being involved in a dense cicatrix. A year after the attack he became epileptic, and from that time he had been subject to very frequent fits, often to three or four a day.

The eyeball was removed in May, 1882, and the removal was succeeded by immediate relief from epilepsy. He was seen several months later, when the

* This case was reported in "The Alienist and Neurologist" for January, 1880.

trouble had not returned, but has since then not been seen.

H. J. R. applied, bringing a letter from his attending physician, Dr. W., May 15, 1880. The patient has been subject to epilepsy for two years. At first, attacks occurred once in two weeks, but under the influence of large doses of bromides the frequency was reduced to about once in three weeks, an improvement which continued from March, 1879, to June following. Then, while still using the same medicine, the attacks increased in frequency, averaging once in four days.

Seizures have, of late, been followed by marked psychical disturbances. There is much mental confusion; he does not recognize friends, and sometimes wanders far from the scene of attack before consciousness returns.

The patient is a miner, and is much of the time forced to look sharply upward. Examination of the eyes shows hypermetropia $\frac{1}{36}$; adducting power reduced to 10°, abducting to 2°. Glasses were directed, and the unyielding muscles trained to greater flexibility. In two weeks the adducting power was 50° and the abducting 9°.

The epileptic seizures ceased after the first few days, and the patient was permanently relieved. He has been seen from time to time, his condition has been, in all respects, greatly improved, and he has been free from epilepsy.

Mr. F. H., thirty-two years of age, was sent by

his physician, Dr. William H. Robb, of Amsterdam, New York, March 12, 1880.

The patient was a man of large frame and finely developed, yet from his early youth he had been subject to serious nervous affections. As a child and lad he had suffered from intolerable headaches, especially during school-days. These were usually accompanied by nausea and often by vomiting. In 1872, after a severe illness, he became subject to epilepsy. His attacks increased from year to year in frequency and intensity. During the past year attacks of great violence and of long duration occurred every month, while others of less severity occurred every few days. He continued to be the subject of dull headaches and of pain in the back, was habitually and excessively constipated, and was extremely irritable. His memory was impaired, and he was constantly subject to a state of mental confusion.

He was found to have insufficiency of the external recti muscles, and on the day of his first visit an operation for tenotomy of one of the interni was made.

The relief was so decided that he visited his family physician on the same day to express his satisfaction. It was, as he declared, as though a load had been removed. Within the next three months three attacks of *petit mal* were experienced. Great improvement in health was manifested from the beginning. No other attacks have occurred during the four and one quarter years, and he no longer suffers from mental confusion, from head or back aches, he is no longer

constipated, and, indeed, declares himself in every respect well.*

The following case of hystero-epilepsy is introduced here as one of much interest in this connection, even if not strictly within the class of cases under discussion :

A young lady was seen at the request of and in company with her physician, Dr. Thomas Featherstonhaugh, in 1879.

During many months the patient had been in a distressing condition of hystero-epilepsy. Epileptiform attacks occurred several times a day, or, in some instances, single attacks lasted nearly the whole day, and during the intervals she was in a state of great nervous excitement. Her physician, who had spent much of his time, both day and night, in attendance upon the patient, had adopted every means at his disposal for her relief, even to the administration of chloroform on several occasions, the administration having been on some of these occasions continued for hours at a time.

The girl was remarkably pale, the pulse was rapid, the skin was cold and moist, and there was a bellows-murmur with the first sound of the heart. The ophthalmoscope did not reveal any important refractive error, but while under examination the eyes were observed at times to turn toward the nose with strong spasmodic action. The pupils were found widely dilated, as though under the influence of atropine. These conditions suggested insuffiency

* Freedom from epilepsy continues (1887).

of the externi, with enfeebled action of the ciliary muscles from habitual suppression of accommodation.

The attending physician was advised to apply a solution of pilocarpine to the eyes, with a view of stimulating the ciliary muscles. This was done, and the nervous phenomena quickly disappeared. The convulsions ceased, and did not reappear after the first day of this treatment. The young lady within a day or two visited the doctor at his office, quite free from her malady, and there has been no return of it to the present time.

Miss L. was sent with a letter from her attending physician, Dr. F. H. Stevens, now of Lake George, New York, May 23, 1882. She had had epileptic attacks during more than two years. She had been subject to headache and neuralgia as long as she could remember. She had also during a number of years suffered much pain in the epigastric region. During the first year of epilepsy, fits occurred usually once in a month, in connection with the menstrual periods, but during the last year she had had attacks every two or three days. The convulsions were perfectly characteristic of the more severe form of epilepsy.

Examination of the eyes showed hypermetropic astigmatism 1 D. Before the use of atropine, there was apparent *myopic astigmatism* 1 D, showing that an extreme tension of the muscles of accommodation existed. After continuing the use of atropine for some days, with the result of changing the refractive state

from apparent myopia to actual hyperopia, cylindrical glasses were prescribed and used.

June 5th, she was seen; had had no epileptic seizure nor headache.

October 27th, seen again; still no return of epilepsy or of headache.

April 24, 1883, called at my consulting-room; still no return of the disease.

From the attending physician it is learned that the young lady has continued well up to the present writing, more than a year and a half since her first visit.

[Mr. H. T., aged thirty-seven, consulted, June 3, 1880, by advice of his physician, Dr. Charles G. Clark, of Troy, New York. He has been an epileptic five years; has had seizures from four to six times a day. Is in other respects in very poor health, looks dull and lethargic. He has used bromides freely up to the present time.

He was found to have hyperopia of $\frac{1}{30}$ for one eye and of $\frac{1}{24}$ for the other, with insufficiency of the externi. July 10, 1880, tenotomy of the internus of one eye was made, followed a few weeks later by similar operation on the other eye. All medicines were discontinued from the first.

On the day preceding the first operation he had had five severe epileptic fits, and on the morning of the operation several more. From the date of the first operation, however, the epileptic attacks ceased, and not a single return of the malady has

occurred up to the present time.* His health improved in all respects.]

[I. B., aged fifteen, was brought for examination by the advice of her physician, Dr. A. H. Allen, of New London, Connecticut, April 17, 1884. She was in early childhood an intelligent and in most respects a healthy child, subject only to nervous attacks. At the age of twelve she became an epileptic, subject to severe attacks from three to five times a day. These attacks were characterized by severe convulsions and total unconsciousness, lasting from ten to thirty or more minutes. In addition to these severe attacks, the milder seizures of *petit mal* occurred many times a day. Evidences of the deplorable effects of the disease upon the girl's mind were soon manifest. She became dull, morose, and feeble-minded, losing from month to month the vivacity which had characterized her in earlier years.

After making use of such means for relief as were suggested by several competent physicians with little or no favorable result, her parents were induced, a year before her first visit to me, to administer in large doses a secret preparation which proved to be mainly a saturated solution of bromide of ammonia.

Dementia, after this treatment, became the most pronounced feature of her disease. The fits were less frequent, and indeed were at one time absent during several weeks. It was known, however, that the failure even for a day or two to administer

* This relief has continued up to the present time (1887).

the drug would be followed by a renewal of the attacks, and during the two months preceding her visit to me, notwithstanding the use of six drachms of the solution daily (about 240 grains bromide), the fits had returned in nearly the former frequency. The face was devoid of any expression of intelligence, and saliva flowed from the angles of her mouth. When attempting to speak, as she did only in monosyllables, the voice was smothered in the fluids of the mouth. Indeed, the patient presented a typical picture of marked dementia.

Her attendants believed that she did not see well, and as nearly as could be ascertained there was slight apparent myopia, with $\frac{20}{40}$ vision. The eyes being brought under the influence of atropine, the ophthalmoscope revealed hyperopia 1·50 D. There was an appearance of decided insufficiency of the externi, but there was too little intelligence on the part of the patient to admit of any exact determination by the equilibrium tests.

The bromide solution was discontinued at once, and a little wine was administered two or three times daily, and convex glasses 1 D were used. Under this *régime* some improvement in the mental and physical condition could be observed after the first week. The fits, however, became more frequent and severe in proportion to her recovery from the influence of the drug. Thus, during the week ending May 3d there occurred fifteen fits, in each of which unconsciousness continued from ten to thirty minutes. During the week ending May 31st there

were twenty-nine very severe attacks, and attacks of *petit mal* in great numbers.

By the 29th of May, after almost daily trials, it was hoped that some progress had been made in the knowledge of the relations of the eyes, and it was supposed that an insufficiency of the externi of from 10° to 20° at twenty feet existed while using the convex glasses.

With a clear understanding, on the part of the father of the girl, of the difficulties attending the determination of precise conditions under the circumstances, and with his full approval, an operation for insufficiency of the externi was made on the right eye, June 4th, and two days later a similar operation on the left, after which the appearance of the eyes was improved, and little if any insufficiency was shown by the tests, such as could be made.

June 1st, she had five fits.

June 2d, she had seven fits; and,

June 3d, she had five.

From June 4th (the day of the operation) *to June 14th no attacks occurred.* From June 14th to June 21st she had eight attacks. June 21st to June 28th, three attacks, all of which were unusually light. No *petit mal* since June 4th.

July 7th, she returned home, her last attack having occurred June 25th. The change in her mental condition had been since the operations truly marvelous, and her physical condition had equally improved. The photogravures, Figs. 1 and

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2, Plate III, exhibit the changes of physiognomy which occurred during a single month. Fig. 1 is from a photograph taken just preceding the first operation; Fig. 2 is from one taken a month later.

From time to time the patient has been seen. She continues in robust health and her intellect has returned. An attempt to send her to school, some months after her return home, was followed by a very slight relapse, but her friends were advised to wait a year before allowing her much close use of her eyes. A year after this her condition continued good with no return of the malady, and a year and a half after the operation, her physician wrote that she continued well. (I have heard, indirectly, just as this manuscript is about to be sent to press, that the girl has a renewal of her attacks. If so, she has, beyond a doubt, some remaining muscular disability, which may still be removed.)] *

J. P., aged fourteen, April, 1883. Was fairly well, with the exception of an attack of pneumonia, until a year ago. Then had his first attack of epilepsy. During the year has had twelve severe attacks at intervals of about a month, and many attacks of *petit mal.*

Examination of the eyes showed hypermetropia. Right 2 D, left 2·25 D. Insufficiency of external recti 7°.

Glasses for partial correction of hypermetropia were used, and on the 23d of April partial tenotomy of the internal rectus of the right eye was made,

* Case introduced in present edition.

followed by a similar operation upon the internal rectus of the left on the 29th of April. May 1st, no insufficiency of the recti muscles is manifest.

The last attack of epilepsy occurred April 20th, three days before the first tenotomy. He has been well, even in respect to *petit mal*, more than seven months.*

G. S. G., July, 1883. During the past year has had quite a number of epileptic attacks, does not know exactly how many. Has a feeling of indefinable nervousness, and his mind is so much affected that he has been forced during the whole year to abandon his business, that of an apothecary. Has suffered much inconvenience during the past eight years from constipation.

He has astigmatism corrected by, right eye 1 D cylindrical, axis 90° ; left eye 0·75 D cylindrical, axis 90°. There are also slight insufficiency of the external recti muscles and deficient adducting energy.

The patient was advised to use correcting glasses, and his eyes were exercised by means of prisms.

No further attacks have occurred, the obstinate constipation is entirely relieved, and the patient writes, under date of November 21st, that he is quite well.

[Miss M., aged twenty-nine. Subject to epilepsy and chorea from the first year of her life. Epileptic attacks occur from three to five times daily. Occasionally the fits are of great violence, but they

* Nothing has been known concerning this patient since the above record was written in 1883.

Plate IV.

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usually last only a few minutes. She has never, since her first year, taken objects in her left hand, that side being most affected by chorea. The left elbow is drawn forward and strongly against the chest, the hand turned palm outward, backward, and upward. The left arm, and in less degree the whole body, are in constant and violent motion. If an attempt is made to bring the arm into its normal position, the whole body becomes convulsed, the face distorted, and both arms move wildly. The visual anomalies were hyperopic astigmatism, right eye, 1·00 D; hyperopia, 1·00 D, left; insufficiency of the externi, amounting to diplopia of 5° when red glass was used, and hyperphoria, 2°. The hyperphoria and astigmatism were treated with cylindro-prismatic glasses. Tenotomy of one internus was done under great difficulties, owing to the patient's mental state, November 22, 1884, and of the other, January 3, 1885. Great relief followed the first operation, and the fits ceased from the 1st of December. In a month she was able to use the left hand for the first time in twenty-eight years to a considerable extent, and delighted in showing how she could brush the windows of the consulting-room with a napkin. Her intellect improved, and, as will be seen by the portraits (Figs. 1 and 2, Plate IV; No. 1 taken November 17, 1884, No. 2, February 2, 1885), her head came to the normal position, and her appearance in every respect was better. Up to April 20th, when the last record was made, there had been no return of epilepsy.

I have, however, learned that during the summer the fits returned in less frequency and degree. A recent letter from her sister informs me that it is the purpose of her friends to pursue the treatment which resulted so favorably still further as soon as circumstances allow.*]

The statement of the cases given above demonstrates beyond a doubt that, in the treatment of epilepsy, examination of the conditions of the eyes is of supreme importance, and that with sufficient attention to this factor among causative influences tending to epilepsy, marked progress may be expected in its treatment.

It is further to be remembered that relief obtained by removal of causes is radical, permitting a complete return to health; while relief following the employment of bromides is only such as is obtained by a prolonged dulling of the nervous susceptibilities, and can only cure by this blunting process, which, even when resulting in any continued arrest of attacks, leaves the patient in a deplorable mental and physical condition.

MENTAL DISORDERS.

A process of irritation, so prolific of nervous disturbances as difficulties in performing the visual function has been shown to be, must, in the nature of the case, react upon the mental as well as upon the sensorial operations of the nervous system.

It is not within the design of this essay to discuss the subject of mental alienation further than, in pass-

* This case is not in original MS.

ing, to apply the principles already established to this department of investigation.

Many instances of acute mania as well as of more chronic and less violent forms of mental disturbances have been known to recover in a manner truly surprising, upon relief being afforded from some perplexity in the ocular operations.

Thus, a young lady who had been a victim of acute mania three months, who had already spent two terms of eighteen months each in lunatic asylums, and who was known to have inadequate accommodative power, returned to her normal mental condition at once upon stimulating the accommodative muscles by eserine.

A lady who had been a teacher and had worked very hard became the subject of hallucinations. She imagined herself a wheelbarrow, and that she was being trundled about. She became at once incapacitated for any employment, and was, after some time, taken to a sanitarium, where she continued during nearly a year and a half. During this time the hallucination changed, and she imagined a face looking over her shoulder and into her own. If she was awake in the night the face was with her, and if she walked or rested it never left her. She was tormented with incessant and violent headache; slept very poorly, and was too weak to endure any but the most trifling exercise.

She had insufficiency of the external recti muscles, which was relieved by operations upon the internal recti.

On the morning following the first operation she

awoke without the presence of her demon, which has never returned; with the second operation her headache disappeared, and she was within a few weeks in vigorous health.

During more than a year she has provided for herself by her own labor as a copyist, and has continued in excellent health.*

This case is fairly representative of several others which need not be related.

[Plate V represents a most remarkable change in the condition of an insane young man. The history of the case is as follows:

The patient was brought to me by his parents, who brought also a letter from Dr. P. M. Wise, Superintendent of the Willard Asylum for the Insane. According to the history given by the parents at their first visit, October 12, 1886, the boy had been insane a year and ten months (according to the report of neighbors, much longer). During a season of unusual religious interest the boy became unquestionably insane. His condition was gradually more and more hopeless until his friends determined to commit him to the asylum. It was when at this institution that they were advised by Dr. Wise to take the patient to New York. When first seen he was stolid, refusing to speak, and sadly demented. He wept aloud, and wrung his hands much of the time. He refused food, and, indeed, for many

* The author is permitted to refer, in connection with this case, to Dr. R. Speakman, Wellesley, Mass.; Dr. A. H. Allen, New London, Conn.; and Dr. J. Blake Robinson, New York.

Plate V.

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months had only taken it as it had been placed in his mouth by others. If standing, he held his arms out in an imbecile manner with the fingers spread apart. The saliva flowed in streams from his mouth to the floor. He was thin and pale, and a cold moisture covered the skin. In this pitiable condition it was difficult to obtain exact information of the ocular conditions, but by the exercise of much patience these conditions were sufficiently made out to enable a generally correct judgment to be formed. Under atropine he showed hyperopia 1·00 D, with insufficiency of the externi 4°. On the 14th of October the first photograph (Fig. 1) was taken, and on the same day a tenotomy of one of the internal recti was done, and two days later a similar operation was made on the opposite internus. From that day an improvement could be seen in the lad's mental state. Within a week he was so much improved as to amaze those who had seen him in his first condition. He soon began to take food of his own accord, and in two weeks he was in a fair way to complete recovery. On November 2d the second photograph (Fig. 2) was taken, eighteen days after the first; and three weeks from the day of his first visit he returned to his home, no longer insane. His friends were advised to bring him again after a few weeks, which they wisely did. Slight hyperphoria was then found, and a tenotomy of one of the superior recti was done. When he returned home the second time he was, so far as could be detected, perfectly well.

The photographs show more than I am able to tell, but even they do not convey a perfect idea of the wonderful revolution which had taken place in the mental and physical condition of the boy in eighteen days].*

[Plate VI is introduced here as representing one of the cases treated by attention to ocular conditions at the Willard Asylum for the Insane during the summer of 1886. Space does not permit of a history of any of these cases, but the photographs fairly represent the average change of physiognomy in these people who had, during many years, been confined in an asylum].*

It follows, then, that in mental troubles, also, the condition of the eyes should be carefully inspected, and sudden and gratifying relief will often reward attentions intelligently directed to any embarrassment which may hinder them in the performance of their offices.

HEREDITY.

Enough has been shown in the discussion of neuralgia to render it evident that to a certain extent the construction of the eyes constitutes an important element in hereditary predisposition to neuroses.

The orbit and its contents are facial features, which are, in their general form and relations to other parts of the face, characteristic in families. The resemblances so strikingly exhibited in many families depend very largely upon the construction of this portion of the face. The form of the eyeball and the length

* In present edition only.

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of the straight muscles are materially modified by the form of the orbit. A broad, flat face at once suggests to the oculist a hypermetropic eye. A narrow face, with prominent features, is more likely to be associated with a lengthened eyeball, and, if the bones of the face are quite unlike on different sides, there is a presumption of astigmatism. With many exceptions, these general rules afford a tolerable estimate of the conditions of the eyes; but with varying depths of the orbit there must also be varying lengths of muscles. In many families a want of equilibrium of muscles is as characteristic a feature as hypermetropia or astigmatism.

Thus in the family of case No. 91 of the table, at page 145, the patient had hypermetropia, and had also converging strabismus. She had one brother and three sisters, all of whom were cross-eyed. Oculists often meet with such instances. Hence, the muscular balance of the eyes as well as their refractive condition enters largely into the composition of family similitudes.

If, then, the eyes in certain families are, as facial features, generally too short, or if there is in the family a tendency to squint, even if the tendency is not manifest to the ordinary observer, there is imposed upon that family an inordinate task, either in accommodating the eyes for near points or in maintaining parallelism of the visual lines. While the subjects of such defects are in full vigor, or while the parts subjected to the unusual demand are used but moderately, there may result little or no inconvenience.

There is under these circumstances sufficient nervous energy to supply the ordinary draft upon the nervous system and to perform this extra task; but if other excessive calls upon the nervous energy are made and the surplus vigor is expended, the difficult task of adjustment or of accommodation can no longer be performed without manifestations of nervous exhaustion. Hence, so long as no assistance is rendered to these overtasked muscles, disease or nervous prostration arising from their disability is exceedingly chronic, and long periods of rest with tonic medicines are required in order that a sufficient amount of reserve energy may be acquired to perform their function and also the requirements of active life.

The same nervous irritation does not always react in the same manner. This is well shown in Brown-Séquard's experiments in tickling. One subject laughs, another cries, a third has contortions of the limbs, and the fourth tetanic rigidity of the muscles.

In case of irritation from difficult accommodation from refractive anomalies or excitation from muscular insufficiencies, family characteristics, such as hypermetropia or insufficiency of the externi, for instance, react in various ways. One member of a family suffers from migraine, another from chorea, and a third from neurasthenia. Again, in one such family the neuropathic tendency consists in eyes of insufficient length, while in another family the tendency may originate in a want of equilibrium of muscles. Thus the various forms of features, when deviating from an ideal standard of anatomical perfection, may give

rise to a great variety of anomalous conditions of the eyes.

It is very generally supposed that nervous diseases prevail to a greater extent in our own times than formerly. Should this prove to be true, which is quite likely, it is interesting to consider, in connection with this supposed increase of nervous troubles, the fact that at the present time the eyes are pre-eminently the working organs of the body.

When the amount of voluntary effort of the muscles of accommodation and adjustment of the eyes demanded by the exigencies of modern civilization from all but the most unskilled class of laborers is considered, it must be seen that in this may be found an explanation of any increased tendency to nervous diseases.

In several hundred instances the history of diseases to which members of families have been subjected has been ascertained with as much accuracy as possible. In a certain proportion the history has been obtained through several generations, but, as it is in most cases impossible to obtain any history beyond immediate relatives, efforts were principally directed to obtain a record of the present condition of parents, brothers, and sisters, if living, and of the cause of death if not living.

It is unnecessary to occupy the space which would be required to exhibit all this research, and a table is appended to this essay in which is shown the results of the inquiry in one hundred cases which are consecutive with certain exceptions here explained.

The cases chosen are all cases in which a specified

form of nervous disease existed and from which the patient was seeking relief. All cases of simple myopia or cases in which the refractive error is less than 1 D, and all cases of simple muscular insufficiency have been rejected from the list.

Myopia is a variable condition, and may arise from other anomalous forms of refraction. Slight refractive errors may or may not be the expression of a family characteristic; and muscular insufficiencies may often result from refractive errors. Hence all these cases, in which the hereditary influence is questionable, are left out.

The list, then, contains consecutive cases of nervous diseases in which the family record has been ascertained, and in which refractive errors of 1 D or more, excluding cases of simple myopia, have been found.

The exclusion of muscular insufficiencies appears necessary, and yet unfortunate; for, while these conditions are often acquired they are also not unfrequently hereditary, as has been shown.

The list of cases consists of adults, the ages ranging from seventeen to sixty-four years, and the family record contains none but immediate relatives—parents, brothers, and sisters.

In order to avoid complications which might arise from including the diseases incident to childhood, and especially as there is often a want of knowledge on the part of those of whom inquiry is made as to the nature of disease from which infant brothers or sisters may have died, all children under the age of twelve years have been excluded from the family record.

We have thus a fair representation of the classes of disease to which families, in which refractive errors prevail, are subject.

It will be seen that chronic nervous diseases prevail in nearly all these families, and it should be remarked, in passing, that in family records in which neuralgia, headaches, and other nervous troubles are said to exist, it is in every instance to be understood that the disease is chronic, one to which the person is habitually subject; and occasional or temporary ailments are in no case included.

There appear in this table fevers and other acute diseases, but by far the greatest proportion of deaths has occurred either from very chronic complaints or from sudden strokes like apoplexy or diseases of the heart. If it is remembered that cerebral apoplexy is often the result of an atheromatous condition of the arteries, and that death from heart-disease, although occurring suddenly, is often the result of old lesions, the list of mortality from continued causes is increased.

The cause of death most frequently noticed is consumption, there being, among two hundred and seven deaths in these families, eighty-nine from this cause.

Consumption is, in the death register of every city, an important item.

Among the deaths of persons more than ten years of age in the city in which these records were made, in years in which no epidemic prevailed, less than twenty-five per cent were attributed to consumption. In these families in which considerable refractive errors

prevail the proportion is much greater, being no less than forty-three per cent.

In the same city the average proportion of deaths from Bright's disease is about four per cent, while in this list about seven per cent have died of that disease.

Paralysis and apoplexy constitute five per cent of the death-rate of the city, while in the table the proportion from these diseases is nine per cent.

A careful study of this record of disease in families with high degree of refractive errors must impress every thoughtful student with the following important truths:

1. In such families there is an extraordinary prevalence of nervous disorders, including migraine, neuralgia, insanity, and organic lesions, such as apoplexy and paralysis.

2. That consumption and Bright's disease are rife in these families.

3. That the higher the grade of refractive anomalies, the greater is the proportion of these last-named diseases.

It can not fail to occur to one who compares this table with the facts given in this essay that families in which such features are transmitted are subjected to unusual nervous tension in respect to a most important function, and that this waste of nervous energy in performing an ordinary task renders the members of such families easily subject to chronic irritations of important organs not necessarily in the immediate vicinity of the seat of the loss of power. Hence, again, such

complaints as pulmonary consumption are but little amenable to medical treatment for the reason that the primary cause continues.

If the patient with phthisis is found also to be the subject of a marked refractive anomaly or of pronounced insufficiency of the recti muscles, his chances of recovery under medical treatment must be greatly enhanced by relieving him of these unnecessary burdens.

Again, in families predisposed to diseases of this class it must be evident that much may be done to avoid them by relieving the unfavorable conditions which may otherwise lead to disease.

THE TREATMENT OF NERVOUS DISEASES.

From what has gone before, it follows as a necessary conclusion that attention to ocular conditions should occupy a prominent place in the treatment of nervous disease.

In the series of cases upon which the conclusions arrived at in this essay have been based, the use of drugs has been almost entirely excluded. In rare cases medicines for relief of temporary symptoms have been administered, but it can not be said that the results, even in these exceptional cases, have been to any considerable extent attained by means of drugs.

Nevertheless, it can not be questioned that medicines which act as tonics or in various ways tend to the promotion of general vigor must be valuable. In the same manner, rest and change of air and scene are known to exert influences favorable to the temporary

relief of almost every form of neurosis; mental emotions of a pleasing character and the influence of hope and courage are all powerful auxiliaries in the treatment of this class of complaints.

All these facts are too familiar to need more than a passing acknowledgment of their value.

If these means have been, to a certain extent, ignored in the treatment of these cases, it has been in the conscientious hope that by confining the efforts strictly to what, in such cases, has been supposed to be the primary cause, less of doubt in regard to the results of treatment, and as to the nature of the difficulties which it was hoped to remove, must exist.

In this connection the teachings of the illustrious Graefe in regard to asthenopia are extremely appropriate.

Speaking of spontaneous cures, and of cures by certain measures not radical, he says: * "In these cases of temporary asthenopia, fresh air, cold water, tonic medicines, and electricity are indicated. What disappears under such treatment is only the symptoms of asthenopia, while the disturbance of the equilibrium of the antagonistic muscles remains and the least sinking of energy recalls the former difficulties."

In like manner neuralgia, chorea, and other nervous difficulties may disappear under similar treatment, but it is the pain or irregular nervous action which has disappeared while the essential difficulty may remain.

Leaving, then, the discussion of these means, so

* "Archiv für Ophthalmologie," Band 8, II, 346.

familiar to all, some points in regard to the removal of causes may be briefly stated. Although so large a proportion of cases find their origin in ocular conditions, the search for irritating causes should by no means be confined to that class of influences. The state of the ear, carious condition of the teeth, the constriction of a passage, even of one so small as the nasal duct, all may act as permanent or primary causes of disease. One instance has been cited above where the removal of a mass of cerumen from the ear has been followed by immediate relief from a long-continued and severe neuralgic affection. Several instances of relief from nervous affections by the dilatation of constricted passages might be given, and the relief sometimes obtained from the removal of decayed teeth is familiar.

Respecting the corrections of ocular defects, so little has been left by the illustrious masters Donders and Graefe and by other learned ophthalmologists that little need be said here, except to ask some consideration for a few points which have received less attention than their merits would justify.

The use of prisms for gymnastic exercise has been frequently mentioned in these pages. Too many happy results have followed the use of this simple method for increasing the tone of the ocular muscles, to leave a doubt of its eminent value.

In cases of slight difference in the refractive condition of the eyes, as, for instance, a very low degree of astigmatism of one eye and emmetropia of the other, there frequently arises, for reasons which need not be discussed here, a want of complete adducting or

abducting power, or of both, which may not depend upon any very considerable degree of insufficiency of the ocular muscles, such as might be demonstrated by the equilibrium test at six metres, yet this deficient power for easy co-operation of the eyes is an important factor in asthenopic and other nervous symptoms.

By causing the patient to look at an object placed at a distance of six metres, directing him to avoid diplopia by the action of the adducting or abducting muscles, as the case may demand, while prisms of gradually increasing strength are placed before the eyes, these muscles are separated in their action from the action of the accommodation and the increased ability to adduct or abduct, soon shows the increase of tone of the muscles.

In the text-books on ophthalmology the subject of insufficiency of the internal recti muscles is discussed, and some of its results were shown, with directions for treatment. The subject of insufficiency of the external recti, however, has been almost wholly ignored.

Graefe, indeed, refers to this subject,* and says that he has performed tenotomy of the internal recti on two occasions. He seems, however, not to have met with signal success, for he declares that the method remains more interesting than practical in comparison with the more peaceful choice of spectacles.

A few other attempts have been made in this direction, but the result of all seems to have been the dropping of the subject by universal consent.

* "Archiv für Ophthalmologie," Band 8, II, 321.

That insufficiency of the external recti muscles is a condition equally or more perplexing in the function of adjustments of the eyes than insufficiency of the internal recti, the author of these pages can not doubt. The effects, however, are less immediate. The patient affected with insufficiency of the internal recti rises, perhaps, from the perusal of a book with aching eyes; but the subject of insufficiency of the externi may return from the opera or other assembly where the eyes have been held fixed upon distant objects, to suffer from migraine on the following day. Neurasthenia, chronic headaches, hallucinations, vertigo, and insomnia are among the frequent results of insufficiency of the external recti.

Three hundred and fifteen operations for the relief of insufficiency of the external recti have been made by the author in cases where no converging strabismus existed. In each case patients were able to maintain and were accustomed to maintain binocular vision, but at an expense of greater than the normal effort.

The operation is performed by bringing the tendon forward by means of a hook, as in the operation for strabismus, when the central fibers are divided at the sclera, allowing the borders of the tendon and the attachments of the capsule to remain uncut.

The operation demands careful judgment and much delicacy of manipulation on the part of the surgeon. The custom of introducing a blade of the scissors beneath the tendon and cutting down upon it, as in operations for strabismus, can not be safely followed in these cases. The division through the conjunctiva is

made exactly over the insertion of the tendon, and about one fourth of an inch in extent. The point of a fine blunt-hook is then introduced very exactly at the tendinous insertion, and the latter is put upon the stretch. A pair of blunt-pointed scissors then cuts down between the hook and the sclera, dividing carefully each way from the center by several little cuts. The capsular connection at the borders of the tendon must, in all cases, be preserved. The insertion of the tendon is somewhat fan-shaped. By dividing all but the extreme fibers at the borders, the tendon lengthens slightly, while the division of the external fibers leaving a central band, as has been proposed by some who have suggested partial tenotomy of the externi in cases of insufficiency of the interni, results in very little, if any, extension of the tendon.

The advantage of the operation proposed and practiced by myself is, that by means of the extreme outer fibers of the tendon, or where greater relaxation is required, by means of the close connection of the capsule to the outer fibers, a considerable relaxation may be obtained, while the muscle is not allowed to fall back, as it is in the operation for strabismus. The operation can be performed in all essential particulars without the aid of the hook, a fine mouse-tooth forceps being made to seize the tendon at its insertion, while the scissors by successive cuts made perpendicular to the sclera divide it exactly at the insertion.

Relaxation of the desired extent has by this means always been obtained, but the relief to the insufficiency is not always permanent, for the healing process is

sometimes attended with a degree of contraction nearly or fully equal to the advantage gained by the operation, in which case a renewal of the operation upon the same or the opposite eye may be made.

The results have been extremely satisfactory, although, as might have been expected, in attempting a process in surgery which was practically new and before tried only with the most doubtful, if any success, some difficulties have attended the accomplishment of the end, more especially in the earlier cases.

Whatever difficulties may have been encountered, however, have been insignificant when compared with the notable and even surprising advantages resulting in the great majority of instances.

It is not too much to say that the attending disadvantages are less in this than in almost any operation in surgery from which results in any degree commensurate can be expected.

The use of the extract of calabar bean or of the sulphate of eserine applied to the eyes in cases of deficient accommodative energy is often of great temporary benefit in a variety of nervous conditions. Instances have been shown in the foregoing pages in which the use of this agent has been followed by the happiest results, and many more might be given.

In cases in which the tension of accommodation is extreme, the use of atropia applied to the eyes is often followed by immediate relief to nervous symptoms and by removing a chronic condition of tension may, in some instances, effect a permanent relief.

The researches of a class of scientific observers, of

whom Cohn may be justly regarded as the leader, have shown how prevalent among children attending schools are found anomalies of refraction of the eyes.

As the work of these children is to be performed principally with these organs, is it not simple justice to them that the function to be most employed should be enabled to be used with the least possible difficulty?

Children are sent to school with the most complete ignorance on the part of parents and teachers of defects which may demand, on the part of the little ones, great expenditure of nervous force, and they are required to keep apace with those who enter upon the same work with no such incumbrance.

If they fail to perform the task of accommodating and of adjusting the eyes, and at the same time of maintaining their positions in their classes, they are condemned as idle or stupid.

If, on the other hand, by virtue of great persistence and determination, they succeed in keeping abreast of their more fortunate companions, they perform their task at the expense of vital energies, and often lay the foundations for future disease. If it were required that the eyes of children should be examined before entering schools, and if the indications shown by such examinations should be observed, an infinite amount of suffering might doubtless be avoided. And should the custom of giving careful and intelligent attention to the conditions of the eyes become general, there can be no doubt that the prevalence of disease of the nervous centers would undergo a marvelous reduction.

TABLE

Containing the records of diseases in the families of one hundred patients suffering from nervous complaints, and in whom marked errors of refraction have been found. The table includes successive cases between the ages of fourteen and sixty-four, stating the age of the patient, the complaint for which he or she was treated, the refractive condition, the result of treatment so far as it is known, with the physical condition of the living, and the cause of death of those not living, when known, of parents, brothers, and sisters.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
1	46	Headaches.	H. 2·75.	Cured.	Father died of acute disease; mother well; one brother has neurasthenia.
2	38	Neuralgia.	As. 1·00.	Cured.	Father died of cholera; mother died of cholera; one brother died of fever; one sister died of consumption; two sisters well; one brother well.
3	41	Migraine.	H. 1·25.	Cured.	Father died of acute disease; mother has paralysis; two brothers died of Bright's disease; two brothers well; two sisters have nervous diseases.
4	30	Headaches.	Ah. 1.00.	Cured.	Father well; mother well; two sisters have chronic neuralgia.
5	55	Neuralgia.	H. 2·00.	Cured.	Father died of consumption; mother died of paralysis; no brothers or sisters.
6	37	Neuralgia.	Ah. 1·00.	Not known.	Father died of paralysis; mother well; four brothers well.
7	31	Insomnia.	Ah. 1·25.	Cured.	Father died insane; mother has had hemiplegia; three brothers well; one sister well.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
8	41	Neurasthenia.	H. 5·00.	Not known.	Father died of apoplexy; mother well; one brother well; one brother and three sisters died of consumption; one sister died, cause unknown.
9	30	Headaches.	H. 2·75.	Cured.	Father died of Bright's disease; mother well; one brother has paralysis; one brother well; two sisters nervous invalids; one sister well.
10	42	Neuralgia.	H. 1·25. As. ·50.	Not known.	Father died, cause unknown; mother has headaches; one brother died of disease of brain; one brother died of heart-disease; one brother died of consumption; one brother well.
11	45	Epilepsy.	H. 1·50.	Not known.	Father died of pleuritis; mother died of cancer; two brothers died of consumption; one sister well.
12	40	Neuralgia, paralysis.	H. 2·00.	Cured.	Father died of pneumonia; mother died of consumption; one sister died of consumption.
13	48	Neuralgia.	H. 1·75.	Cured.	Father died of fever; mother died in child-birth; one brother is an epileptic; one brother well; one sister has rheumatism; one sister well.
14	26	Epilepsy.	H. 3·00. As. 2·00.	Not known.	Father has rheumatism; mother died of Bright's disease; one brother died from accident; one brother has consumption; two brothers well; one sister well.
15	51	Epilepsy.	H. 1·25.	Not known.	Father well; mother died of consumption; one brother well; one sister has Bright's disease; one sister well.
16	41	Headaches.	H. 2·00.	Cured.	Father died of consumption; mother has rheumatism; two brothers died of consumption.
17	52	Headaches.	H. 2 25.	Not cured.	Father died of fever; mother died of consumption; one brother died of consumption; one brother well; one sister died of consumption; one sister has consumption.
18	24	Neuralgia.	H. 2·75.	Cured.	Father died of cerebral disease; mother well; three sisters well; three brothers well.
19	48	Neuralgia.	H. 1·00.	Not treated.	Father died of cerebral disease; mother died of paralysis; one sister died of apoplexy; one sister died of consumption.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
20	43	Neuralgia.	H. 1·25.	Cured.	Father has neuralgia; mother well; three brothers have neuralgia; one sister has neuralgia.
21	43	Vertigo.	H. 1·25.	Not treated.	Father well; mother has rheumatism; one brother well; one sister has vertigo; one sister has rheumatism; one sister well.
22	51	Headaches.	H. 2·75.	Cured.	Father died of pneumonia; mother well; one brother has headaches; one brother well; one sister has rheumatism; one sister has some nervous disease; one sister died of consumption.
23	51	Vertigo.	H. 2·50.	Cured.	Father died of consumption; mother died of —; one brother has neuralgia; one sister has neuralgia.
24	52	Headaches.	H. 1·75.	Cured.	Father died of consumption; mother died of consumption; one sister has asthma.
25	58	Neurasthenia.	H. 2·00.	Not treated.	Father died of rheumatism; mother died of fever; six brothers well; one sister has consumption.
26	40	Neuralgia.	H. 1·25.	Improved	Father died of epilepsy; mother has migraine.
27	31	Neuralgia.	As. 1·50.	Cured.	Father died of acute disease; mother subject to neuralgia; one sister has consumption; one sister has neuralgia.
28	34	Neuralgia.	Ah. 2·00.	Cured.	Father subject to migraine; mother well; four brothers well; one sister well.
29	40	Neuralgia.	Ah. 1·00.	Cured.	Father died of apoplexy; mother has neuralgia; one brother died of consumption; one brother has consumption; one sister a nervous invalid.
30	64	Headaches.	H. 1·25.	Cured.	Father died of paralysis; mother of pleuritis; one brother of consumption; one brother of some nervous disease; one sister has neurasthenia; one sister died of rheumatism; one sister died of paralysis.
31	53	Headaches.	As. 1·50.	Cured.	Father not well; mother has cancer; one brother well; one sister well.
32	30	Neurasthenia.	H. 1·25.	Cured.	Father died of accident; mother died of paralysis; one brother well; one sister well.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
33	38	Neuralgia.	H. 2·50.	Cured.	Father died of heart-disease; mother has neuralgia; one sister has rheumatism; one sister has some nervous disease.
34	42	Neuralgia.	Ah. 1·00.	Not treated.	Father well; mother well; two brothers have migraine; one brother has neuralgia; one brother died of chorea; one died of dysentery.
35	30	Headaches.	Ah. 1·50.	Improved	Father died of consumption; mother well; three sisters not well.
36	61	Insomnia.	H. 5·00.	Not treated.	Father died of abscess; mother died of consumption; two brothers died of consumption; one sister died of consumption.
37	28	Headaches.	H. 1·50.	Cured.	Father well; mother died of consumption; one brother died of consumption; one brother well; two sisters well.
38	45	Neuralgia.	Ah. 1·25.	Not treated.	Father died of consumption; mother died of cancer; no brothers or sisters.
39	24	Neuralgia.	H. 2·75.	Not treated.	Father has nervous disease; mother has neuralgia; one brother insane; one brother has chronic neuralgia; one brother well.
40	51	Headaches.	H. 1·75.	Not treated.	Father died of fever; mother died of consumption; three sisters died of consumption; one brother well.
41	35	Epilepsy.	H. 2·50.	Improved	Father well; mother has glaucoma.
42	40	Neuralgia.	H. 1·00.	Not treated.	Father died of consumption; mother died of —; one brother died of heart-disease; one brother died of —; one brother well; two sisters well.
43	28	Headaches.	As. 7·00.	Cured.	Father well; mother has rheumatism; one brother has consumption; five sisters well.
44	61	Headaches.	H. 2·25.	Cured.	Father died of fever; mother died of consumption; four sisters died of consumption.
45	49	Headaches.	As. 4·00.	Not treated.	Father died of consumption; mother died of consumption; one sister well.
46	26	Neuralgia.	H. 3·50.	Cured.	Father died of Bright's disease; mother has neuralgia; two brothers well.
47	53	Neuralgia.	Am. 1·50.	Not treated.	Father died of old age; mother died of Bright's disease; one brother of erysipelas; one sister insane; one sister well.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
48	52	Melancholia.	H. 1·00.	Not treated.	Father died of accident; mother died of jaundice; one brother died of fever; one brother well.
49	42	Neurasthenia.	As. 1·00.	Cured.	Father died of consumption; mother well; one brother died of consumption; one brother well; four sisters died of consumption; three sisters well.
50	32	Chorea.	H. 1·00.	Not cured.	Father has chorea; mother well; one sister has chorea; one brother has chorea.
51	42	Spinal irritation.	H. 2·75.	Cured.	Father died of fever; mother well; no brothers or sisters.
52	52	Neuralgia.	H. 1·50.	Cured.	Father died of Bright's disease; mother died of Bright's disease; three brothers well.
53	46	Neuralgia.	H. 1·25.	Not known.	Father died of apoplexy; mother died of angina pectoris; one brother died of consumption.
54	30	Headaches.	H. 2·00. As. 1·00.	Cured.	Father died of consumption; mother died of cholera; one brother died of fever; one brother well; one sister has pulmonary disease.
55	44	Migraine.	Am. 2·00.	Cured.	Father died of consumption; mother died insane; one sister has chronic neurasthenia.
56	30	Chorea.	H. 1·25.	Cured.	Father well; mother well; one brother has asthma; one brother well.
57	44	Migraine.	H. 3·00.	Cured.	Father died of consumption; mother died of consumption; one brother died of consumption; one sister died of consumption; one sister died of paralysis.
58	47	Insomnia.	H. 1·50.	Not known.	Father died of paralysis; mother died of cancer; one sister has neuralgia; one sister died of some nervous disease.
59	40	Neurasthenia.	Ah. 1·25.	Cured.	Father died of cause unknown; mother died of consumption; one brother died of consumption; one sister has neurasthenia.
60	27	Headaches.	H. 3.50.	Cured.	Father died of apoplexy; mother well; one brother well; one sister well; one sister has migraine.
61	37	Insane.	H. 1·00.	Cured.	Father has neuralgia; mother died of apoplexy; two brothers well.
62	54	Neuralgia.	H. 2·50.	Cured.	Father died of old age; mother died of consumption; two sisters died of consumption; one sister well; two brothers well.
63	32	Muscular spasm.	H. 1·50.	Cured.	Father well; mother has consumption; one brother well.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
64	28	Head-aches.	H. 3·00. Ah. 1·00.	Cured.	Father died of consumption; mother well; one brother well; one sister well.
65	19	Head-aches.	H. 1·25.	Cured.	Father well; mother has neuralgia; one brother has chorea; one brother well.
66	37	Head-aches.	H. 2·50.	Cured.	Father died of Bright's disease; mother well; one brother died of pneumonia; one brother has heart disease; three sisters are invalids.
67	52	Head-aches.	H. 1·00.	Cured.	Father died of Bright's disease; mother died of aneurism; one brother died of consumption; one brother well.
68	43	Head-aches.	H. 2·25.	Cured.	Father died of paralysis; mother died of epilepsy; one brother died of heart-disease; one brother has locomotor ataxy; one brother has chronic headache; one sister died of some nervous disease; one sister well.
69	52	Head-aches.	H. 2·25.	Cured.	Father died of fever; mother well; two sisters died of fever; two sisters well; two brothers well.
70	52	Migraine.	H. 1·25.	Cured.	Father died of consumption; mother died of acute disease; one brother died of fever; one brother has nervous disease; one sister died of consumption; two sisters died of cerebral disease; one sister well.
71	42	Migraine.	H. 4·00.	Cured.	Father died of heart-disease; mother died of paralysis; one brother died insane; one brother well; one sister died of tetanus; one sister died of consumption.
72	18	Chorea.	H. 1·25.	Cured.	Father well; mother died of Bright's disease; two brothers well; one sister not well.
73	42	Spinal irritation.	H. 2·50.	Cured.	Father died of disease of heart; mother died of cerebro-spinal meningitis; one sister died insane; one sister was insane; one sister died of locomotor ataxy.
74	14	Epilepsy.	H. 2·25.	Cured.	Father died of Bright's disease; mother well; one brother has headaches.
75	51	Vertigo.	H. 2·25.	Cured.	Father died of consumption; mother died of —; one brother has neuralgia; one sister has neuralgia.
76	52	Head-aches.	H. 1·75.	Cured.	Father died of consumption; mother died of consumption; one sister has asthma.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
77	40	Neurasthenia.	H. 1·75.	Not treated.	Father died of apoplexy; mother died of consumption; one brother died of fever; one brother well; two sisters well.
78	45	Migraine.	Am. 1·75.	Cured.	Father died of consumption; mother died of consumption; one brother well; five sisters all have migraine.
79	51	Neuralgia.	H. 1·25.	Cured.	Father died of heart-disease; mother died of heart-disease; one brother died of —; one sister died of —.
80	44	Neurasthenia.	H. 1·00. As. 0·50.	Cured.	Father died of apoplexy; mother died of consumption; two brothers well; one sister well.
81	56	Headaches.	H. 1·75.	Cured.	Father died of pneumonia; mother died of cancer; two brothers well; one sister well.
82	37	Neuralgia.	H. 1·00.	Cured.	Father died of —; mother has neuralgia; one sister has neuralgia.
83	24	Headaches.	Am. 16.	Cured.	Father has migraine; mother died of acute disease; one sister died of fever; three brothers well.
84	31	Neuralgia.	H. 0·50. As. 1·00.	Cured.	Father died of angina pectoris; mother well; one brother died insane.
85	40	Spinal irritation.	Ah. 1·00.	Cured.	Father died of spinal disease; mother died of consumption; one sister well.
86	20	Neuralgia.	M. 4·00. Am. 1·50.	Cured.	Father died of pneumonia; mother has neuralgia; no brothers or sisters.
87	19	Neuralgia.	Ah. 1·75.	Not known.	Father died of pneumonia; mother has migraine; five brothers well; one sister has migraine; one sister well.
88	30	Neuralgia.	H. 1·00.	Cured.	Father has asthma; mother died of consumption; five sisters well.
89	21	Headaches.	Am. 1·00.	Cured.	Father well; mother has headaches; one brother well.
90	17	Headaches.	M. 5·00. Am. 1·00.	Not known.	Father died of consumption; mother died of consumption; two brothers well; one sister has migraine.
91	27	Neuralgia.	H. 1·50.	Not known.	Father died of consumption; one sister has migraine; two sisters well; one brother well; the patient, the brother, and the three sisters all have strabismus.
92	43	Neuralgia.	H. 1·25.	Not known.	Father died of heart-disease; mother has rheumatism; two brothers died of consumption; four sisters died of consumption; one brother well; two sisters well.

No.	Age of patient.	Nature of complaint.	Refractive error.	Result of treatment.	Family history.
93	27	Neuralgia.	M. 4·50. As. 1·25.	Cured.	Father has rheumatism; mother has migraine.
94	37	Headaches.	H. 1·75.	Not known.	Father well; mother has consumption; one sister well.
95	40	Neurasthenia.	As. 2·00.		Father well; mother died of apoplexy; one brother died of consumption; two brothers well; two sisters well; one sister an invalid.
96	21	Headaches.	As. 1·00.	Cured.	Father died of Bright's disease; mother well; one sister has neurasthenia; one sister well.
97	48	Neuralgia.	H. 3·00.	Cured.	Father died of abscess of the liver; mother died of consumption; four sisters well.
98	21	Headaches.	As. 6·00.	Cured.	Father has phthisis; mother an invalid; one brother died of consumption; one sister died of consumption; one brother well.
99	41	Neuralgia.	H. 4·50.	Not known.	Father died of apoplexy; mother well; one brother died of acute disease; one brother died of consumption; three sisters died of consumption; one sister an invalid.
100	24	Neuralgia.	H. 1·75.	Cured.	Father died of heart-disease; mother well; three brothers well; two sisters well.

Summary of the above Table.

Average age (the minimum being fourteen)		39
Average refractive error		2·16
Number treated in which results were known		72
Important relief obtained among these from measures directed to ocular conditions in		67
Deaths among parents		129
From acute diseases	26	
" cerebro-spinal diseases, epilepsy, chorea, insanity, apoplexy, etc.	28	
" consumption	39	
" Bright's disease	14	
" heart-disease and rheumatism	7	
" miscellaneous and unknown causes	15	
Parents living		70
Reported to be in good health	35	
Suffering from nervous disorders	21	
" " consumption	3	
" " rheumatism	6	
" " miscellaneous disorders	5	

Deaths among brothers and sisters		90
From cerebro-spinal diseases	14	
" consumption	55	
" Bright's disease	2	
" acute diseases	13	
" heart-disease and rheumatism	4	
" unknown causes	2	
Brothers and sisters living		221
Reported well	148	
Suffering from nervous diseases	51	
" " consumption	7	
" " Bright's disease	1	
" " heart-disease and rheumatism	5	
" " invalidism	9	

SUPPLEMENT.

If the doctrines set forth in this work are worthy of acceptance, it must follow that a knowledge of the refractive and muscular anomalies of the eyes is essential to the most successful treatment of a very large proportion of nervous complaints. The supplemental portion of this work is prepared with the view of affording the practitioner who does not profess to be a specialist in eye-affections, a general understanding of the anomalies to be sought for and the means for their correction. No effort is here made to present an exhaustive or a critical treatise. One who would pursue these subjects in a technical manner will find abundant material for study in a part of this field in the superb works of Donders and of Landolt upon "The Refraction and Accommodation of the Eye." Unfortunately, there are no text-books in which that class of anomalies of the ocular muscle known as "insufficiencies," is fully discussed. For the most part, the literature of this subject is confined to a single condition of "insufficiency," and even this receives, as a rule, but a passing notice. The reader will, in the pages devoted to this subject, find it treated very

briefly, but it is hoped that this little treatise will enable any intelligent practitioner to form correct conclusions respecting the condition of the eyes of his patients in this respect.

REFRACTION AND ACCOMMODATION OF THE EYE.

The eye may be regarded as an optical instrument, similar, in some respects, to a camera-obscura, such as is used by photographers, in which rays of light are concentrated by means of convex lenses in such manner as to fall upon a screen at the rear of the dark chamber. If the screen is of white ground glass, an image of an object from which the rays emanate may be seen upon the glass by an observer looking from behind the screen.

In the eye, rays of light pass through transparent media, where they are so bent or refracted as to be concentrated upon the retina, where the impression is recognized as the form of the object perceived.

Rays of light passing from space into the eye are refracted, according to Donders, by the anterior surface of the cornea, the anterior surface of the lens, and the anterior surface of the vitreous. The transparent media through which the rays must pass to the retina, and in which the refraction is accomplished, form the *dioptric system.*

The ideally normal eye is so constructed that rays from an infinite distance, that is to say, parallel rays, in traversing the dioptric system, are brought to a focus at the retina without an effort of accommoda-

tion. This normal condition of the eye is called *emmetropia.*

The diagram (Fig. 3) shows the arrangement of the different structures of the eye and the relations of the elements forming the dioptric system. The tough membrane, the *sclera* (S.), maintains the general form of the globe, extending backward to inclose the *optic nerve* (O. N.), and forward as far as the *cornea* (C.). Next within this sclerotic membrane lies the vascular membrane, the *choroid* (Ch.), having an expanse about equal to that of the sclera. The cornea is transparent, permitting rays of light to pass into the eye, where they make their way through the *aqueous humor* (A. H.) and pass through the opening in the *iris* (I.), which is the pupil. The rays then traverse the *crystalline lens* (C. L.) and the *vitreous humor* (V. H.), at length falling upon the *retina* (R.), the delicate nervous membrane which extends from the optic nerve and lies between the choroid and the vitreous humor. If the rays are brought to a focus on the retina, this focus lies at a point somewhat external to the point of en-

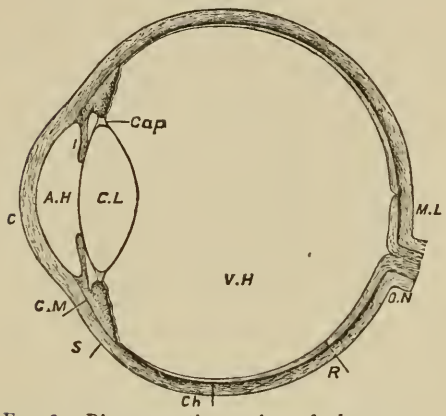

FIG. 3.—Diagrammatic section of the eye. *s*, sclera; *c*, cornea; *i*, iris; *ch*, choroid; *r*, retina; *ah*, aqueous humor; *cl*, crystalline lens; *vh*, vitreous humor; *cap*, capsule; *on*, optic nerve; *ml*, macula lutea.

trance of the optic nerve, where the retina becomes even more thin and delicate than in its general expanse. This point, which is exactly in the visual axis, is called the *macula lutea* (M. L.). The point at which the optic nerve enters the eyeball is called the *optic disc.* The crystalline lens is held in position by an extremely delicate enveloping membrane called the *capsule* (Cap.), which is connected with the muscular ring, the *ciliary muscle* (C. M.).

If an object which is clearly defined upon the screen of a camera be moved nearer to the instrument or carried farther from it, the image upon the screen will be no longer well defined, but indistinct. In this case the clear definition may be restored by changing the relation of the lenses to the screen, by moving them backward or forward, or the lenses may be replaced by others having greater or less refracting power.

If the eye were so constructed that its focal adjustment was always the same, objects only within a certain range would be well seen, and all objects removed beyond or brought within shorter range would be indistinctly perceived. This condition is provided against by the faculty possessed by the eye of changing, within certain limits, its refractive state. This is called the faculty of accommodation, and it must be brought into action whenever the eye regards objects nearer than the most distant point of clear vision; and thus during waking hours it is almost constantly exercised. The theory of the mechanism of accommodation of the eye was long one of the most interesting of

physiological inquiries, and many suppositions and speculations were from time to time accepted. The first to discover and to demonstrate the actual changes which occur in the exercise of this important function was Dr. Thomas Young.

From the era of Kepler until the time of Dr. Young's contributions to the "Philosophical Transactions" in 1801, much had been written and but little had been known of the nature of this faculty possessed by the normal eye of adapting itself to bring to a focus rays of light emanating from points at different distances. Young, by experiments, and by what, had they been properly understood, should have been regarded as conclusive arguments, showed that the change of focal adjustment of the eye in accommodation depends upon alteration in the degree of convexity of the crystalline lens. A similar hypothesis had previously been held, but no demonstrations had been adduced.

Little attention was paid to Young's theory until Helmholtz and Cramer, working independently, proved by mathematical and ocular demonstrations the truth of the theory. This important physiological problem having been solved, it remained to others, and notably to the illustrious Professor Donders, to develop the theories of accommodation and refraction in respect to individual defects. The result of Professor Donders's labors in this direction were given to the world in his great work, "On the Anomalies of Accommodation and Refraction of the Eye," published in 1864.

According to the present knowledge of the function of accommodation, the ciliary muscle, a small muscular ring situated in the interior of the eye and surrounding the border of the crystalline lens, acting upon the lens in such a manner as to modify its curvatures, and hence its refracting power, is the seat of the faculty of accommodation.

According to the investigations of Cramer and Helmholtz, it is shown that in the act of accommodating the eye for near points the lens becomes convex, its anterior surface advancing toward the cornea, while the posterior surface remains nearly stationary, a change produced by the contraction of the ciliary muscle. When this contraction is discontinued, the lens resumes its original form, and the eye is adjusted for distance. The modification of the convexity of the lens, when accommodated for distance and near points, is well shown in the accompanying diagram:

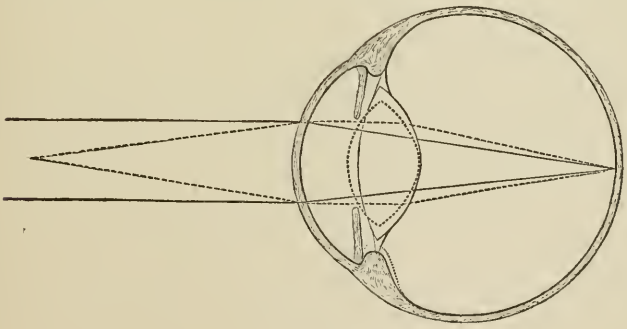

Fig. 4.

In Fig. 4 parallel rays are shown by the solid lines which enter the eye, where they undergo refraction

and meet exactly at the macula lutea. The interrupted or dotted lines represent rays coming from a near point. These rays diverge as they approach the eye. Hence, if they are to meet at the macula, they must be more strongly refracted than the parallel rays represented by the solid lines. To accomplish this the ciliary muscle contracts, thus becoming a ring of less diameter. (The dotted lines at the ciliary muscle show the change in its form). This contraction in the diameter of the ciliary ring relaxes the tension upon the capsule, when, by its innate elasticity, the lens assumes a more convex form, as is seen in its dotted outline. This stronger convex lens now refracts more strongly than before, and thus the diverging rays are brought to a focus exactly at the point at which the distant or parallel rays were when the eye was at rest. As soon as the force of contracting the ciliary ring is removed, its diameter is increased, the tension upon the capsule is renewed, and the lens returns to its original state.

In an ideally constituted eye, the distant point of clear vision (*punctum remotum*) is the horizon or infinite distance. Parallel rays are brought to a focus without effort on the part of the ciliary muscle, and pencils of light from the retina pass out of the eye in parallel rays. Objects situated at about twenty feet from the eye send to it rays which are practically parallel, and hence in ophthalmology objects seen at twenty feet are regarded as at infinite distance.

The distance between the remote point (*punctum remotum*) and the nearest point (*punctum proximum*)

of clear vision, representing the extent of accommodative power, is called the *range of accommodation.* Accommodation is a positive force acting only in producing clear vision as objects approach within finite distance. It can not act to magnify very distant objects by a process of negative accommodation.

The crystalline lens, like every other tissue of the body, becomes less elastic with each year of life. Hence the power of accommodation diminishes and the near point advances toward the distant on account of the constantly increasing difficulty of changing the curvatures of the crystalline lens by the action of the ciliary muscle.

At the age of twenty the near point is at about ten centimetres (eight and a half inches) from the eye, while at the age of forty it has reached to twice that distance, and at seventy-five it has been gradually transferred to the remote point. In other words, the faculty of accommodation is at that age practically lost.

It is evident that in this gradually progressive removal of the near point there must come a time when the normal eye can not clearly see objects within the ordinary distance of reading, and artificial help in the form of glasses becomes necessary. This, to the best eyes, occurs between the ages of forty-five and fifty, and the condition of accommodation demanding such aid is called presbyopia. Presbyopia is not necessarily a failure of visual power, nor is it, as is commonly supposed, an indication of perfect eyes that one is able to read without the aid of glasses after the age of fifty.

People who read without glasses after that age are near-sighted, or have some other defect of the eye.

As the practical treatment of presbyopia is materially modified by errors in the refractive condition of the eye, its further consideration will be resumed after these errors have been discussed.

REFRACTION OF THE EYE.

All eyes are not constructed on the plan which has been shown above. Some eyes are longer and some shorter than in emmetropia, and some have irregular refracting surfaces. These conditions, varying from emmetropia, are, according to Donders, known as conditions of ametropia.

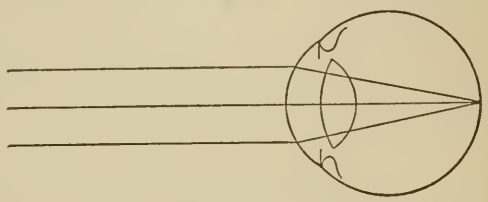

FIG. 5.—This represents the form of the emmetropic eye, in which parallel rays are brought to a focus at the back of the eye, without an effort at accommodation.

If the eye is short, and parallel rays, could they pass beyond the back of the eye, would come to a focus behind the retina, the condition is called *hypermetropia* or *hyperopia* (Fig. 6).

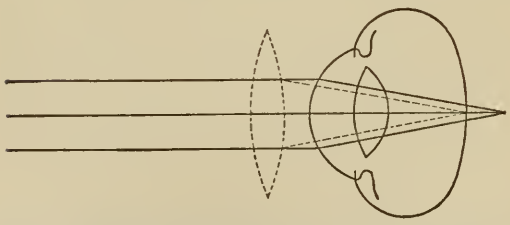

FIG. 6.—The hyperopic or short eye. The solid lines represent the course which parallel rays would take were the back of the eye transparent. A convex lens, placed in front of such an eye, gives the rays the directions shown by the dotted lines, which meet at the retina.

If, on the contrary, the eye is long, and parallel rays come to a focus in front of the retina, the condition is known as *myopia* (Fig. 7).

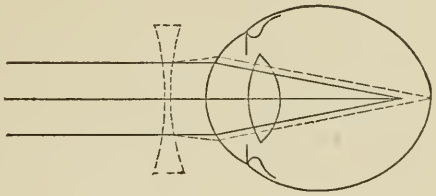

Fig. 7.—The myopic eye. It is too long. Parallel rays, shown by the solid lines, unite before reaching the retina, and must cross and fall upon it in diffusion. A concave lens causes the rays to enter the eye in a diverging manner, and they unite farther back, as shown by the dotted lines.

An astigmatic eye is one in which there is a difference of refraction in different meridians. Thus, in one meridian of an eye, emmetropia may exist; while in a meridian at right angles to this, myopia or hyperopia may be found.

HYPEROPIA, OR FAR-SIGHT (H.).

Hyperopia (Fig. 6) is one of the most common conditions which the ophthalmic surgeon is called upon to treat. It depends generally upon the form of the eye, which is too short, and dates from birth. It does not increase with age, except in a slight degree after the age of fifty, but, if neglected, may pass into the reverse condition, myopia.* As, in this condition, the rays are not brought to a focus at the retina but behind it, when the eye is at rest, even distant objects are not seen clearly, and objects at near points are still less distinctly seen. But if the faculty of accommodation

* Occasionally, also, hypermetropia may arise from too feeble refracting power, on account of flattening of the cornea, or of the surfaces of the lens, or on account of absence of the lens (aphakia), or the refracting power of the aqueous humor or lens may be insufficient.

is called into exercise, distant, and, with greater effort, even nearer objects are seen clearly. The ability thus to bring the focus upon the retina will, however, depend upon the degree of hypermetropia and the power of the ciliary muscle to effect the accommodation. As this faculty of accommodation is exercised without direct consciousness on the part of the individual, the fact that one has good vision, both for far and near points, does not show that hyperopia does not exist.

It will be seen that even in viewing distant objects the accommodation must be used, and a greater demand for its exercise is made in seeing at near points. Hence hyperopic eyes are seldom at rest during waking hours, and a constant amount of contraction of the ciliary muscle is demanded. It is not surprising, therefore, that hyperopic eyes, especially if required to perform much close work, as in reading or sewing, suffer from a condition of fatigue known as *accommodative asthenopia.*

The symptoms and results of hyperopia are due largely to this fatigue of accommodation, but the perplexity arising from the absence of harmony between the functions of accommodation and of convergence has already been shown in the first part of this work (page 19). If the degree of hyperopia is slight and the power of accommodation active, little inconvenience may be experienced; but if the vigor of the ciliary muscle is diminished, the eyes become painful, a dull, aching sensation is felt in and about the brows, the patient complains that letters and small objects become, after a short use of the eyes, indistinct. The

letters of a page, which at first appear clear, after a short time run together, and it becomes necessary to discontinue the work while the accommodation is relieved. Pressing the eyes with the hand, when this sense of fatigue is experienced, is a common and characteristic means of relief. If the act of accommodation is persisted in after these warnings, severe pain in and about the brow and at the back of the head, general discomfort, and nausea, may follow. As a result of frequent straining of the muscles of accommodation, hyperopic persons often have redness of the conjunctiva and of the borders of the lids. The more general and distant reactions have been shown in the first part of this work.

In the higher degrees of hyperopia visual acuity is often diminished, so that even with correcting glasses the visual power is considerably less than the standard.

Donders, to whom we owe the knowledge of the relations of these symptoms of fatigue to hyperopia, divides the condition into latent and manifest hyperopia.

In latent hyperopia the patient unconsciously uses his accommodation, and thus conceals a part or the whole of the refractive error. This is especially the case with young persons, in whom the power of accommodation is active, if the degree of hyperopia is only moderate; but even a high degree of hyperopia may be associated with a vigor of accommodation sufficient to conceal it. As age advances, however, there comes a time when the lens being less elastic than in earlier

life, the accommodation no longer suffices to render even distant objects clear, and still less to enable the patient to read.

The hyperopia is now manifest in part at least. A suitable glass may raise distant vision to the normal standard and the same glass may enable the subject to read.

To ascertain the absolute amount of hyperopia, it is necessary, especially in all young persons, to render the latent hyperopia manifest, which can be accomplished if we suspend the action of the ciliary muscle by atropia or other drugs producing similar effects.

MYOPIA, OR NEAR-SIGHT (M).

Myopia is the condition opposite to hyperopia. The axis of the eye being usually too long instead of too short, as in hyperopia, parallel rays are brought to a focus in front of the retina, and, before reaching it, cross and fall upon it in circles of diffusion (Fig. 7).

Hence, rays must be divergent as they enter the eye in order to meet at the retina. The far point of vision, then, for a myopic eye, instead of being at infinite distance, is brought nearer, and a myopic eye is consequently a near-sighted eye. The distance of the remote point of distant vision will depend upon the amount of elongation of the eye. If this be slight, there will be a correspondingly slight degree of myopia, or near-sight. If, on the contrary, the elongation be great, there will exist an excessive degree of near-sight.

Myopia, when dependent upon anatomical forma-

tion, is scarcely modified for the better by treatment, but unless suitable precautions are used there is a strong progressive tendency. Cases of slight myopia, if neglected, are liable to develop rapidly into high degrees of near-sight. It is important, therefore, that the first indication of near-sight in children should receive the most careful attention. The popular prejudice which existed formerly that near-sight diminishes with age is erroneous, and should never be an excuse for relaxing the most vigorous attention to even the slightest degree of myopia. A slight change in the length of the eyeball after the age of fifty is, in this connection, a matter of technical rather than of practical interest. My own observations have convinced me that myopia is very frequently, if not in general, one of the results of anomalies of the ocular muscles, and that the condition most conducive to myopia is that in which the visual line of one eye tends in a higher direction than that of the other.

In low degrees of myopia the defect may escape observation, as objects within certain distances are clearly seen, and the fact that objects beyond this point are not well seen is not regarded by the patient as in any way peculiar. Indeed, people with moderately high degrees of near-sight often become aware of their defect for the first time by accidentally putting on concave glasses, which reveal to them objects at a distance in a manner to them surprisingly clear. Usually, however, it will be observed that the myope holds a book or work nearer than the usual distance, and fails to recognize distant objects as well as other

people. In low or moderate degrees, glasses are not required for reading or writing, but in higher degrees work must be brought very near to the eyes in order to obtain distinct images, and in these cases concave glasses enable the myope to carry the book or other work to the ordinary distance. In near-sight, if of only moderate degree, the accommodation is commonly used in reading and the book is brought near the eyes; but, as age advances, the eye becomes presbyopic in the same manner as in emmetropia. The near point recedes toward the distant point, and thus, while the subject of myopia can see at no greater distance than before, there is a necessity for removing objects for near view toward the distant point. The slight change in the refractive condition which has been alluded to above, must not be considered here. The range of vision, then, is less extensive, but the near-sight remains. It was upon the facts that the book is held at greater distance, or that the glass for near-sight must be left off while reading, that the popular error that near-sight decreases with age was founded.

Examining the history of near-sight in an individual, it will, in the majority of instances, be found that until the age of from ten to fifteen years, vision for distance was good, but that near-sight, then appearing, developed rapidly. In a certain proportion of instances, however, myopia is developed at a very early period of life, and in a very small proportion of cases it may be congenital.

The subjects of near-sight often suffer from redness

of the eyes and eyelids, from pain in the brows and general headaches, from intolerance of light, and from the presence of motes in the field of vision.

Near-sighted eyes are commonly diseased eyes. The rapid elongation of the eyeball is often associated with disease of the choroid, and in some instances with separation of the retina from the choroid. A condition called *posterior staphyloma*, in which the sclerotic is distended backward, is often developed in myopia. The principal changes, as described by Donders, are "atrophy of the choroidea on the outside of the optic nerve, when myopia is highly developed, combined with change of form of the nerve-surface, a straightened course of the vessels of the retina, incomplete diffuse atrophy of the choroidea in other places, and morbid changes in the yellow spot." These changes can be readily recognized by the aid of the ophthalmoscope. Fig. 8 shows the irregular, white crescent which marks the atrophy of the choroid.

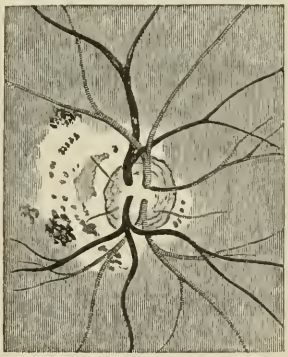

Fig. 8.

Besides the elongation of the axis of the eye, myopia may be the manifestation of the increased index of refraction of the dioptric media or of excessive curvature, as in conical cornea.

A condition of involuntary and excessive contraction of the ciliary muscles (*spasm of the accommoda-*

tion) sometimes occurs in young persons simulating myopia, and generally, after a time, resulting in the anatomical changes of myopia. If recognized in season the contraction of the ciliary muscles can be relaxed by the use of atropine continued for several days, and thus one suffering from apparent myopia and threatened with organic myopia may by this simple measure be saved from a great impending misfortune. Even this relief may, however, be only temporary, for if the cause of strain or irritation which in the first instance induced the spasm of the ciliary muscle is permitted to remain, the same spasm may return. Hence, as soon as the spasm is relaxed, every effort should be made to find and to remove the source of trouble, which is likely to be found in some unfavorable relations of the motor muscles of the eyes or in some perplexing state of the refraction.

Myopia prevails mostly among the educated classes. The tension of accommodation demanded in looking during many hours of the day at near objects acts as an immediate cause. This cause becomes intensified in case the light is insufficient or is badly arranged. Hence the evils of badly-illuminated school-rooms have, very properly, engaged the attention of those who have studied the causes of myopia. Repeated examinations in schools and universities on a large scale have shown that myopia is progressive from the lower to the higher classes, a greater percentage of myopia existing in the higher classes than in the lower. This increase in the percentage of myopia is not to be wholly accounted for by such causes as de-

fective light or illy-constructed desks. The cause must be sought for in conditions more radical than these. The relations of the ocular muscles constitute, in my opinion, the most important predisposing cause of myopia, and in this direction the most careful search should be made and the most judicious precaution should be exercised. This, however, should not for a moment encourage any relaxation from the most minute regard for the hygiene of the school-room or of offices or other places in which the eyes are brought into prolonged use at close range. Defective light, impure air, and too greatly-prolonged exercise of the accommodation of the eyes, all conspire to act as immediate causes of myopia.

Myopic children naturally find less pleasure in out-of-door amusements than other children, and are inclined to employ much of their time in reading. This inclination should be checked, and the amount of close work performed by the child should be rather less than in excess of the amount of similar work allowed to an emmetropic child.

ASTIGMATISM.

Parallel rays of light traversing a convex spherical lens (not regarding spherical aberration) unite beyond the lens in a luminous point. If the lens be bent in such manner that the curve in one direction is greater than in another, say at right angles to the first, the rays are not united in a point, but rays passing through the part of the lens most strongly curved unite first; those traversing the part or meridian of

weaker curvature unite at a greater distance behind the lens. If the rays after passing through such a lens were received upon a screen, they would form not a point, but a line.

In the emmetropic eye the dioptric system may be regarded practically as a spherical lens, but in astigmatism the refraction is not uniform in all the refracting meridians. In what is called regular astigmatism, difference of refraction exists in different meridians, the greatest and least refractive power being in the meridians at right angles to each other. If *a c*, Fig. 9, be the meridian of greatest refraction, *c d* is that of the least.

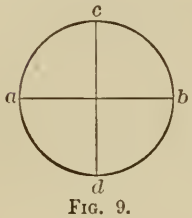

FIG. 9.

In irregular astigmatism there are different degrees of refraction in different parts of the same meridians. It is often a result of ulcer of the cornea or of irregularities in the form of the lens. It is seldom much benefited by glasses.

Regular astigmatism exists in different forms. If the meridian of greatest refracting power is emmetropic, if its rays unite at the retina, and the meridian of least refracting power be hyperopic, its rays uniting behind the retina, it is called *hyperopic astigmatism.*

If the meridian of highest refracting power is myopic, its rays uniting in front of the retina, and the meridian of least refracting power be emmetropic, it is *myopic astigmatism.*

If both the meridians of greatest and least re-

fractive power are hyperopic, one more than the other, it is *compound hyperopic astigmatism.*

If both meridians are myopic, one more than the other, it is *compound myopic astigmatism.*

If one meridian is myopic and the other hyperopic, it is *mixed astigmatism.*

Astigmatism, in most instances, depends upon defective curvature of the cornea, which, instead of being curved in all directions alike, is more strongly bent in some directions than in others.

The general effects of astigmatism are similar to those of the defects of refraction already described. In low degrees, little inconvenience may be experienced in the act of seeing, although it is evident that a perfect image is not obtained. In the higher grades much more trouble of sight results, as there must, of necessity, be much confusion in the focal adjustment for lines constituting an image, those which are more or less nearly at right angles to one another being subject to different focal adjustments.

In reading, the astigmatic, like the myopic person, brings the book near the eyes. There is generally, in high degrees, defective vision even when correction by glasses is made, and hyperæmia of the retina is not an uncommon complication.

EXAMINATION AND TREATMENT OF AMETROPIA.—TEST-TYPES.

Any two points of a retinal image, in order to be distinguished from each other, must have between them a certain distance. This distance has been

shown by many experiments to correspond to a visual angle of about one minute in the emmetropic eye. Taking this principle as a basis, Snellen constructed his system of "test-types," which has been universally adopted for the demonstration of the acuteness of vision.

The objects adopted are letters, graduated in size, both as to the parts and the whole, to correspond to different distances from one foot to two hundred feet.

In order to test the acuteness of vision, letters are placed at a point sufficiently distant to exclude the act of accommodation. The point most generally selected is twenty feet, or about six metres, and an emmetropic eye, with normal acuteness of vision, should read the characters of No. XX (No. 6 of the new system) at twenty feet. If only No. XL can be read at twenty feet, the visual acuteness is $\frac{20}{40}$, or only one half the normal. If only the type which should be read at one hundred feet is read at twenty feet, the visual acuteness is $\frac{20}{100}$. Thus the numerator of the fraction denotes the number of feet at which the eye is withdrawn from the type, while the denominator shows the line of smallest characters which can be read. In noting the result, we write, vision $\frac{20}{20}$, if normal, or vision $\frac{20}{40}$ or $\frac{20}{60}$, as the case may be.

In general, the subject of the examination is not allowed to approach nearer than twenty feet; but if vision is very defective, he is allowed to approach until the largest types are read. Thus vision may $= \frac{5}{200}$, etc., the numerator showing the distance as before.

The types used for near vision are, of necessity,

smaller. The smallest should be read at eighteen inches. They are used chiefly for testing accommodation.

The following is copied from Snellen's types:

0.5 D

The Gallic tribes fell off, and sued for peace. Even the Batavians became weary of the hopeless contest, while fortune, after much capricious hovering, settled at last upon the Roman side. Had Civilis been successful, he would have been deified; but his misfortunes, at last, made him odious in spite of his heroism.

This type should be read with ease at the distance of one half metre, but in testing the accommodation the subject is required also to read it at twelve inches.

The types of No. XX (6. D, new system) are shown below.

If the person examined reads No. XX at twenty feet and No. 0.5 at about one and a half foot (one half metre), he is assumed to be emmetropic. He is not myopic, as he would not be able to read the characters at the greater distance. He may, however, be hyperopic, and by the exercise of accommodation distinguish the letters. If No. XX is not clearly seen with the unaided eye, but is clearly seen with a convex spherical glass, the focal length of the glass indicates the degree of manifest hyperopia. Thus, if the focal length of the glass is forty inches, the manifest hyperopia is $\frac{1}{40}$, or in the more modern system, 1. dioptry (H manifest = 1. D).

If, on the contrary, a concave spherical glass of

forty inches negative focus (1. D) is required to render No. XX distinct, then myopia is $\frac{1}{40}$, or 1. D (M = 1. D).

In determining astigmatism, radiating lines, the rays equaling in thickness the limbs of the letters of No. XX, are used.

In testing the refraction with types at the distance of twenty feet the accommodation should be completely relaxed. This is most effectually done by dropping into the eye, two or three hours before making the test, a small quantity of a solution of atropine of the strength of four grains to the ounce of water. This is rarely necessary after the age of forty, and not always even before that.

According to the system which has long been in use, a lens is numbered according to its focal length, and its refractive power is represented by a fraction, of which the numerator is 1 and the denominator the focal length in inches. Thus, a glass of twelve inches focal length has refraction of $\frac{1}{12}$.

A new system has, within a few years, been introduced, in which the unit of refraction is no longer $\frac{1}{1}$ inch, but a lens, the focal length of which is 1 metre. This is called a dioptry, and the refracting power is $\frac{1}{1}$ metre. A lens of twice the refracting power would consequently be $\frac{2^m}{1} = 2$ dioptries. A lens of one half the power $(\frac{.5\,0^m}{1}) = .50$ dioptry. If we wish to find the focal distance of a lens of this system we reverse the fraction. Thus a lens of 1 D $= \frac{1}{1} = 1$ metre; one of 2 D $= \frac{1^m}{2} = \frac{1}{2}$ metre. As the degree of ametropia is expressed by the lens which corrects it, the sev-

eral degrees of refractive error are indicated in dioptries. Thus, if by the old system H = $\frac{1}{40}$, by the new H = 1. D; and if M = $\frac{1}{20}$ old, M = 2. D new; M $\frac{1}{13}$ = 3. D.

A given number of dioptries may be reduced to the old numbers by dividing by 40 (40 inches being nearly 1 metre). Thus 1. D ÷ 40 = $\frac{1}{40}$; 2. D ÷ 40 = $\frac{1}{20}$; 3. D ÷ 40 = $\frac{1}{13}$; and reversely the old numbers may be reduced to the new.

Applying the principles of the test-types and lenses to the examinations of difficulties of refraction and accommodation, we shall be able, in a given case, to apply lenses which shall serve to reveal objects clearly at a distance, or assist vision for reading and writing, as the case may demand.

In determining the defects in refraction the examiner should first carefully inspect the general appearance of the eye, observing its form and relation to its fellow, as well as any indication of clouds upon the surface of the cornea or of opacities behind the pupil. The acuteness of vision should be tested without the aid of glasses, and again with glasses. The condition of the interior of the eye should be carefully determined by the aid of the ophthalmoscope, and evidences of imperfection in the refracting media or of disease of the deep structures carefully noted.

In the diagnosis of ametropia the ophthalmoscope and various optometers may be used. In practice, however, a case of trial-glasses is absolutely necessary. With a view of furnishing a portable and comparatively inexpensive case of trial-glasses, such as may

be fully equal to the requirements of the general practitioner, but which does not include glasses unnecessary except after cataract operations or in rare cases, the author has devised a case which he believes fully meets the requirements.

The object is attained by including in a single set of lenses all those numbers more commonly in use. All the numbers of spherical lenses contained in Nachet's large case up to 10. D (old No. 4), are retained, with such other glasses as are best calculated to produce all the higher denominations with the least trouble. By combining not more than two lenses at one time, all the numbers of the best trial cases may be readily obtained. A similar arrangement holds in regard to cylindrical lenses. Numbers frequently required correspond to those of the most complete trial cases, while all the others can be obtained with perfect ease by simple combinations.

The lenses are constructed upon the metrical system; hence, combinations can be made without any complex mathematical calculations.

The case also contains a set of prismatic glasses, opaque and stenopaic disks, plain and colored glasses, and an adjustable trial-frame. With this trial case, all the examinations in regard to refractive conditions or muscular anomalies can be made as conveniently as with the most complete and expensive case.

If the examiner, being provided with suitable trial-glasses, wishes to ascertain the refractive condition of the eye to be examined, he excludes the other eye from the act of vision by placing in his trial-frame an opaque

disk, or by any suitable device. The person examined is now requested to read the letters of the trial-card, and the extent to which the letters are seen is noted. If the letters of No. XX are read at twenty feet, we conclude that myopia does not exist, and we are to determine the presence or absence of hyperopia or a moderate degree of astigmatism. The myopic vision is unable to adjust by accommodation for a distant point, but one in whom the faculty of accommodation is active may conceal a low degree of astigmatism or a high degree of hyperopia. If the patient sees as well with a convex glass of any denomination, as without, manifest hyperopia, equal to the strongest glass thus accepted is proved. But let us suppose that the type of No. XXX is read, and that No. XX can not be clearly made out. Vision is then $\frac{20}{30}$, and if no disease or obstruction exists it may be hoped that vision can be raised to $\frac{20}{20}$. First, a very weak convex spherical glass (·50 D) is placed before the eye; if vision is somewhat improved, a stronger and stronger may be tried, until the best results are attained. But, before the eye becomes fatigued, the effect of a weak convex cylindrical glass should be compared with that of the spherical. The cylindrical glass should be placed in various positions before it is rejected. If the convex spherical aids vision and the cylinder does not, to an equal extent, simple hyperopia is to be assumed. In case neither the convex spherical nor cylindrical lens aids vision, but rather renders the characters indistinct, concave spherical and then cylindrical glasses are to be tried in the same manner. In case neither assists the eye, we

are to assume that no refractive error exists, unless, with the ophthalmoscope, we are able to discover the refractive anomaly. We have emmetropia with but $\frac{20}{30}$ vision.

If the eye subjected to examination is hyperopic, and is fully under the influence of atropine, the *absolute* hyperopia may be discovered; otherwise, we can determine only the *manifest* refractive error.

The strongest glass which is found to give additional sharpness of detail to the letters represents the degree of manifest or absolute hyperopia, as the case may be. It is not to be forgotten that when atropine or some other mydriatic is not used, a certain amount of hyperopia may remain latent; that the sum of the manifest and latent hyperopia equals the total. Hyperopia which may be latent at one time may become manifest at another. Hence the glass which appears to correct the manifest refractive error at one time may be found at a later time to be too weak.

If a convex glass of 1·00 D corrects the absolute hyperopia, then H = 1·00 D; but if it is only the manifest hyperopia of an eye which may, under the circumstances, exercise its accommodation, H m = 1·00 D.

The question of the extent to which glasses should be used in hyperopia is an important one.

Theoretically, the accommodation should be relieved from all but the amount of exercise which would be required in emmetropria, but practically it is found more convenient, in many instances, to allow the eye to subject itself to a certain amount of accommodative effort at a distance.

Children with moderate hyperopia need not, as a general rule, use glasses for distance. But if an insufficiency of some of the ocular muscles exists, there may be an advantage in their use even for distance. If the child suffers from nervous complications, such, for instance, as chorea or headaches, it may also be advisable to employ the glasses habitually. In other cases a glass of rather less strength than corrects the absolute hyperopia is to be used for near work. In high grades of hyperopia, or in case of loss of accommodation from age or other cause, the hyperopia should be corrected for all distances.

After the age of forty-five or fifty, most hyperopic persons will require two pairs of glasses: one for correcting the hyperopia, to be used for the distance; the other stronger, neutralizing both the hyperopia and presbyopia.

Let us suppose that, in the case already assumed, a convex glass does not improve but rather dulls vision at the distance of twenty feet, and that a concave glass serves to render the letters of the trial-card more distinct. Myopia is to be assumed, and the weakest concave glass giving the most distinct vision at twenty feet, the accommodation being relaxed, represents the degree of myopia. In determining the degree of myopia, we begin by selecting a glass of low and gradually of higher power, until the lens affording the greatest improvement in vision is found. We may form an approximate conclusion in respect to the degree of myopia by finding the greatest distance at which ordinary print can be read. We estimate the distance at which

the page becomes indistinct, which indicates the far point of vision. If this is less than the distance at which the same page would be read by the emmetropic eye, myopia is presumed.

If the distant point for reading the type No. ·50 be one fourth of a metre (about ten inches), we have, approximately, myopia 4·00 D, or $\frac{1}{10}$. We may now try the effect of a negative glass of 4·00 D (of the old system No. 10), generally with the effect of enabling the letters to be carried to the distance of half a metre, and of materially improving vision at the distance of twenty feet. We now seek for the weakest glass that will enable the patient to see well. It is not to be forgotten that the strongest convex glass with which the patient can see well at a distance, and the weakest concave glass with which vision is not less acute than with those of stronger power, represent respectively the manifest hyperopia and the grade of myopia.

If, now, in the case above supposed, we can obtain a slight increase of vision, or even equal vision, by placing in front of the 4·00 D lens a weak convex glass, say of + ·50, our correcting glass is too strong, and must be reduced to the extent of the value of the second glass. On the contrary, if a weak concave glass assists, we must increase the strength of the original glass in a corresponding degree.

In practice, the subject of myopia should always use the full correcting glasses for distant seeing, but this may be less convenient for near work. The accommodation is often enfeebled in myopia, and the effort at adjustment for near points, such as would be

required for the emmetropic eye, may become wearisome. In this case glasses should be used of less strength than those demanded for distance, or if the myopia is of but very moderate degree, glasses may be left off in reading. Again, if the distance at which the eyes are to be used is such that the individual does not see well without glasses, and is fatigued by the use of those employed for distance, we may reduce the strength of the glass according to the distance required. Thus, if the distance is that for ordinary reading (about one half metre), we reduce the glass 2·00 D ; but if the glass is required for a somewhat greater distance, as for instance by a public speaker who wishes to refer to his notes, or by one who would read music at a piano, we estimate the distance at about thirty inches, or three fourths of a metre, and deduct from the strength of our glass 1·33 D, or, in practice, 1·50. We find the amount of such deductions by dividing 1 by the distance in decimals of a metre. Thus, for one half metre, $\frac{1\cdot00}{\cdot50} = 2\cdot00$ and $\frac{1\cdot00}{\cdot75} = 1\cdot33$. As the nearest approximate number to this last in the trial-cases is 1·25 or 1·50, we may select, according to the case, the stronger or weaker number.

The determinations of refraction are not always as easy as in cases of simple hyperopia or myopia. In a very considerable proportion of cases of anomalous refraction astigmatism exists. This may render the diagnosis of the precise refractive error extremely difficult, and much practice and skill may be required in arriving at a proper result. The general rules for determining astigmatism are not so complex that they may not

be understood without much difficulty, but in practice the examiner will often find that he must rely largely upon his own tact and experience rather than upon fixed rules. The tests for astigmatism depend upon the fact that an astigmatic eye, in looking at lines drawn at different angles with the horizon, sees some lines more clearly than others. On this principle, the fan of Snellen and the radiating lines of Green are constructed. A reduced copy of each is here represented. The thickness of the lines is made to correspond with the thickness of the limbs of the letters of the test-types for twenty feet.

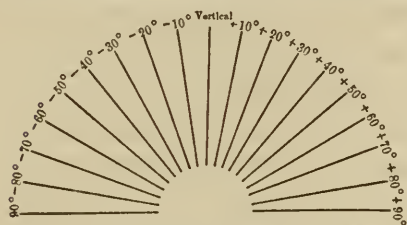

FIG. 10.—Dr. Snellen's test-lines for astigmatism.

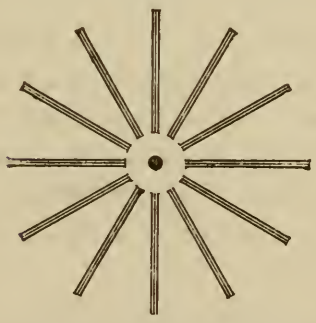

FIG. 11.—Dr. Green's test-lines.

After satisfying ourselves that, in the case to be examined, there is an absence of disease of the interior of the eye and of obstructions to the passage of light, tests for hyperopia and myopia are made.

The examiner having ascertained whether either of these conditions exists, corrects any hyperopia or myopia which may be found with a convex or concave glass, as the case may be. If neither of these conditions is found, no spherical glass will be required.

If, then, there remains a defect of vision, the patient is required to state whether the radiating lines are all seen equally well. If one line or group of lines is seen with greater clearness than the others, this line indicates the meridian of the eye in which the fault is to be found. If the lines of Dr. Green are used, we inquire, first, respecting the contrast between the vertical and the horizontal group. As these bear the numbers of a clock-dial, we find, for instance, whether the group from XII to VI is more or less clearly seen than the group from III to IX, or, in other words, whether the vertical is more distinct than the horizontal, and many like questions, if need be, in order to understand the location of the contrasting groups. Having learned that one group of lines, for instance, that from III to IX, is most clearly seen, the examiner places a cylindrical lens before the eye with its axis at right angles with the line best seen, in this case vertically, or, as marked on the scale of the trial-frame, at 90°. A convex or a concave spherical glass may now be found which will render this horizontal line as clearly visible as the line at right angles to it was at first, and the value of this glass will represent the difference of refraction of the two meridians. Or, a convex cylinder may be first used, when, if it proves unsatisfactory, a concave cylinder of low power is tried.

If, with a convex cylinder of low power, with its axis at a right angle to the line most clearly defined, the diagram appears in all respects more plainly visible and more uniform, we have hyperopic astigmatism.

If, on the contrary, a concave cylinder similarly placed is demanded to improve the clearness and uniformity of the lines, we have myopic astigmatism.

In either case the strength of the cylindrical glass which renders the lines most perfectly seen in all meridians represents the degree of astigmatism. The diagnosis of a low or moderate grade of myopic astigmatism in a young person should not be accepted if atropine is not used.

The test-letters should now be brought into requisition, and if, with the glass selected, the best possible vision is obtained, it is the glass to be ordered for constant distant use and for all purposes, if presbyopia does not exist. Much may be gained in certain cases by varying the strength of the glass while examining with the test-letters, and, in case that both a spherical and a cylindrical lens may be demanded, we may alternately weaken or strengthen one at the expense of the other.

In case of the demand for both spherical and cylindrical lenses, we have compound astigmatism. In this case we first find the spherical glass which will render one line clear, then leaving this glass in place we test for the cylindrical, which will render the ray at right angles to it clear.

In mixed astigmatism the correction is first made either by a spherical glass, as above directed, when a cylindrical glass of opposite refracting quality is used to correct the opposite meridian. If, for example, a convex spherical glass of 1·00 D corrects the horizontal meridian, while a concave spherical of 1·00 D renders

the vertical line most distinct, we may, in this case, use a convex spherical of 1·00 D, combined with a concave cylindrical equal in strength to the spherical, together with the degree of myopic astigmatism, that is, of 2·00 D with its axis horizontally; otherwise we may employ a convex cylindrical glass of 1·00 D with its axis vertical, combined with a concave cylindrical glass of 1·00 D with its axis horizontal. These two combinations will produce practically the same result, and will make all parts of the diagram equally distinct, and hence effect a correction of the astigmatism.

It is evident that glasses for the correction of astigmatism must not only be ground to meet the indications of the unequal errors, but that they must be accurately placed before the eye in order to correct the proper meridians. The frames which accompany the best boxes of trial-glasses are supplied with a scale on which is engraved the degrees of a half-circle, by which the examiner is enabled to determine and prescribe the position of the axis of each glass. Certain signs are, for convenience, employed by oculists in prescribing or recording the elements of compound glasses. Let it be required to prescribe a glass composed of the following elements: Spherical + 1·00 D combined with cylindrical + 0·75 D, with its axis at 90°, we write:

$$S + 1{\cdot}00 \supset \text{cyl.} + 0{\cdot}75,\ 90°.$$

If two cylinders, a convex and concave, are to be combined, convex 2·00 D at 90°, with concave 1·50 D at 1·80°, we write:

$$\text{cyl.} + 2{\cdot}00,\ 90° \lceil \text{cyl.} - 1{\cdot}50,\ 1{\cdot}80°.$$

The method of examination described above is a

convenient one, but is only one of several which may be used, according to the inclination of the oculist.

Astigmatic eyes are often poor eyes, and vision is, in some cases, only moderately improved by correcting-glasses at first, although in a certain proportion of cases marked improvement may be observed after several months.

UNEQUAL REFRACTION OF THE EYES (ANISOMETROPIA).

It is not uncommon to find a difference in the refraction of the two eyes. One eye may be emmetropic and the other myopic, hyperopic, or astigmatic, or there may be different degrees of ametropia in the two eyes.

If the difference is small, it is best to correct the error of each eye. If, however, there is great disparity of the refractive conditions, much difficulty may be experienced by the patient in trying to correct both. In such cases there is usually found very marked anomalous tendencies of the ocular muscles which seriously complicates the situation. Before glasses perfectly adapted to each eye can be used with comfort in such extreme cases, it is necessary to establish muscular equilibrium, after which there is a better prospect of harmonious action of the two eyes.

TREATMENT OF PRESBYOPIA.

It has already been shown that presbyopia consists of the gradual recession of the near point of clear vision toward the distant point. At the age of forty-five, owing not to the flattening of the eyeball, as has

been popularly supposed, although a slight change in the length of the axis of the eye actually occurs, but to the loss of elasticity of the crystalline lens, the emmetropic eye finds some difficulty in reading fine type, especially in the evening. According to Donders, the near point of clear vision in the emmetropic eye is, at the age of ten, two and two-thirds inches in advance of the eye; at twenty it is three and a half; and at forty a little more than eight inches removed from the front of the eye. There is, then, no absolute point where the change to presbyopia commences, and the selection of a point which shall be regarded as presbyopia is entirely arbitrary, based upon the needs of the great majority of those who require glasses on account of advancing age. Donders fixes the point of commencing presbyopia as that at which the near point has receded to more than twenty-two centimetres, or about nine inches in front of the eye.

Adopting this as the commencement, we determine the degree of presbyopia in a very simple manner. If we bring small letters (No. 0·5) toward the eye until we find the nearest point of clear vision, we calculate the difference between this point and the point of commencing presbyopia; thus:

Presbyopia $= \frac{1}{9} - \frac{1}{n}$; n in the formula represents the near point ascertained. If $n = 12$ inches, then the formula reads:

$$P = \frac{1}{9} - \frac{1}{12} = \frac{1}{36}.$$

Presbyopia then $= \frac{1}{36}$, and a glass of thirty-six inches focal length is required to bring the near point to nine inches.

Substituting the metrical system, in which a lens with the focal value of nine inches is represented by 4·50 D, and one of twelve inches by 3·25 D, and our formula will be

$$4{\cdot}50 - 3{\cdot}25 = 1{\cdot}25.$$

The following table indicates the lenses which, according to Donders, are required for presbyopia of emmetropia at different ages:

Age.	D	Inches.	Age.	D	Inches.
45	1·00	1/40	65	4·50	1/9
50	2·00	1/20	70	5·50	1/7
55	3·00	1/13	75	6·00	1/6½
60	4·00	1/10	80	7·00	1/5½

It must not be supposed that every pair of emmetropic eyes will find these glasses exactly suited to the necessities of close work. The distance at which work is to be done is to be considered in the selection of the glasses; thus a public speaker who reads his notes while speaking will require glasses, other circumstances being equal, weaker than one who works at a desk. Again, vision of emmetropic eyes, through the influence of muscular insufficiences or other causes, is not unfrequently less than the normal standard. Hence, glasses must be adapted especially to the individual.

It is evident that if hyperopia, myopia, or astigmatism exists, either condition must be taken into consideration. If hyperopia exists, the amount must be added to the degree of presbyopia shown in the table. If myopia is present, it is to be deducted; and

in a case of astigmatism, the value of the correcting cylinder is to be added or subtracted.

In determining the glasses required in an individual case we employ test-types. Those in most general use for this purpose are Snellen's. These types are so graduated as to represent the greatest distance at which they should be read. Thus the smallest (see page 169), 0·5 D, should be read at one half metre (eighteen inches), the fourth at one metre (forty inches), and the sixth at 1·50 metre.

In testing presbyopia, we first correct the ammetropia by placing the proper glasses in the trial-case. The patient is then required to read the smallest types which can be read, and the nearest and farthest points are noted. In practice it is advisable not to force the eyes to read the smallest type at nine inches, but at a somewhat greater distance; twelve inches may be accepted. If the patient, in holding the card at twelve inches in front of the eyes, is able to read the types marked 1·25, and none smaller at this distance, we may place glasses of 1·25 D in the frames. It will now be found that No. ·50 can be read at twelve inches. The type is then to be removed to the distance indicated by the number 0·50 (eighteen inches), and if it can still be read at this distance, there is a reasonable amplitude of accommodation, and the glasses are not too strong.

If the patient is quite myopic, the fully-correcting concave glasses may be left out of the trial-frames, and the weaker glass, which will permit the small types to be read at the specified distance, may be chosen.

In concluding this sketch of the subject of refraction and accommodation, it will not be out of place to call attention to some general points of interest which are incidentally related to the subject.

Ametropic eyes — eyes varying from the ideal standard—are very common. It is an ordinary occurrence for the oculist to find persons who believe that they are blessed with the best of vision, and who boast of its excellence, to have really quite defective eyes, and perhaps very indifferent vision. To assume that one has excellent eyes because the name of a distant steamboat can be read by the possessor when others do not read it, or because the letters of a sign-board are seen when one's neighbor does not read them, is to presume that all the other persons who may be looking at these objects have perfect eyes, and that their attention has been equally directed to the object. Such tests prove nothing, and should not lead one to assume a perfection which may not exist.

A very popular error is the supposition that one must have "strong" eyes because their possessor is able to see small objects better than others, and such a person is likely to boast of the ability of one or both parents to read without glasses until at an advanced age. It has been shown already that, when people who have passed the age of fifty are able to read without glasses, it is an indication, not of perfect eyes, but of myopia; and when people see minute objects better than usual, we also conclude that they are near-sighted.

Many people who have refractive or muscular disa-

bilities suffer from a certain degree of intolerance of light. To avoid the inconvenience arising from ordinary daylight, it is a not uncommon practice to employ tinted glasses. It is even the practice of some oculists to prescribe such. The practice is not one to be commended. If the eyes do not tolerate the light, the reason for the intolerence should be learned and removed. Proper attention to the refractive or muscular states will, in the great majority of instances, afford complete relief.

In case of disease of the eye, or in facing extreme light, colored protectors may be of temporary advantage.

The material of which lenses should be made, and the manner in which they should be adapted to the face, are subjects worthy of consideration.

Many people suppose that "pebbles" or lenses made of rock-crystal are much better than those made of glass. This is a popular error. The crystal has only the advantage of greater hardness, while it has the disadvantage of greater expense, and is very often less perfect optically than the glass lens.

Glasses should be so adjusted to the face as to bring them in proper relation to the eyes. Formerly nearly all eye-glasses were so made as to hang downward upon the face, greatly interfering with the symmetry of the facial lines, and forcing the eyes to look through the borders of the glasses.

Recently much improvement has been made in this respect. Such glasses should be made to permit the light to pass directly through the optical center of the

glass to the pupil. The borders should correspond with the lines of the brows. The glasses should be large, and the frames should not be conspicuous. Under these circumstances the natural expression of the face is not interfered with, and the glasses are much less conspicuous than when the facial lines are broken up.

There is a general prejudice against the early employment of glasses for presbyopia. It is thought that the eye should be forced to perform its function as long as possible without artificial assistance. This, if the condition were one of temporary failure of muscular tone, might be logical. In the actual state of the eyes such a prejudice is unwise. The eye in presbyopia is required to exert an amount of force which is entirely inconsistent with the well-being of the eye itself or of its possessor. If one persists in forcing the eyes to do close work without glasses after presbyopia has commenced, the muscular power fails, and presbyopia increases more rapidly than if proper relief is given at the right time.

AFFECTIONS OF THE OCULAR MUSCLES IN WHICH BINOCULAR VISION MAY BE MAINTAINED.

In the study of the relations of ocular conditions to disturbances of the nervous system, the affections of the ocular muscles occupy a position of paramount importance.

The complicated system of muscles which co-operate in adjusting the two eyes in such a manner as to obtain binocular vision under a multitude of circum-

stances, affords a subject of research attended by difficulties but rich in interest.

In the act of binocular vision—that is, of vision in which the object seen by the two eyes makes but a single mental impression—the principal optic axes are in such exact relation to each other that a straight line drawn from the object through the pupil falls upon the yellow spot of the retina, the central point of vision of each eye, and at the same time each eye must be accurately adjusted in respect to its focus for the distance from it to the object seen.

With every new adjustment of the eyes their relations must be so precisely maintained as to permit the line from the point seen to fall upon this minute portion of the retina of each eye.

Such ever-changing and extremely nice associated actions are demanded in no other part of the organism. The movements of the extremities, no matter how precise or how delicate, make no such constant demand for minute precision; and from no class of muscles, other than those that direct the eyes and regulate the accommodation, is the maintenance of perfect exactitude of service so constantly required.

That this exacting service should, when difficulties in its performance are encountered, make excessive demands upon the stock of nervous energy of the individual, or result in perplexities or irritations, is not surprising.

Affections of the ocular muscles may be divided into those which result from physiological peculiarities and those which result from pathological conditions.

In the first of these groups, the muscles, while manifesting no indications of disease, do not act in such harmony as to permit the most ready and easy combinations of action. This group is divided into two classes:

1. Those which permit of habitual binocular vision.

2. Those in which a blending of the images of the two eyes is so difficult as to be, in most instances, impossible. The conditions of this class are known under the general term *strabismus.*

The first of these classes has for a long time been known under the name of *insufficiencies of the ocular muscles.*

For reasons which have been fully discussed elsewhere,* this term is regarded as indequate and often misleading. It has been shown that for some of these conditions no distinctive terms exist, and that to others the term *insufficiency* is improperly applied. Terms of more exact meaning are therefore required.

Accordingly, the system of terms relating to the conditions, which was suggested in the works referred to, will be employed here.

In this class of muscular faults, binocular vision is maintained by the expenditure of a greater amount of force than is required when the ocular muscles are in a state of perfect equilibrium. The visual lines are habitually held in such relations as to extend from the point of fixation to the yellow spot of the retina, but

* "Archives d'Ophthalmologie," Paris, November, 1886; "New York Medical Journal," December 4, 1886; "Archives of Ophthalmology," New York, June, 1886.

only by persistent and special effort. The tendency is for the visual lines to part, for one of them to continue to unite the fixed point and the macula or yellow spot and for the other to fall upon some other part of the retina. Such tendencies are grouped under the generic name HETEREPHORIA (ἕτερος, *different*; φόρος, *a tending*).

This term includes the conditions which have been known as insufficiencies of the ocular muscles.

Some of the most distinguished contributors to the science of affections of the eyes have given considerable attention to this subject, yet it has received vastly less consideration than its importance has demanded. To Graefe we are greatly indebted for important researches in this department; and Horner, Nagel, Landolt, and many others, have made valuable additions to the subject. The writings of Graefe were those of a pioneer and were not exhaustive. Others, however, have been content in great measure to accept the results of Graefe's genius as in the main conclusive. The discussion of "insufficiencies" has been mainly, it may be said almost exclusively, confined to a single anomaly, and that not the one of greatest importance.

When the eyes are directed to a distant object situated directly in front of the observer and at a distance of from fifteen to twenty feet, the visual lines are practically parallel, and in this position there should be the minimum of nervous energy directed to the muscles of the eyes. If this is the case, the ocular muscles are said to be in a state of equilibrium and in all other adjustments the changes of relations required are made

with the least expenditure of effort consistent with the action.

This condition, in which all adjustments are made by muscles in a state of physiological equilibrium, is called ORTHOPHORIA (*ὀρθος, right; φόρος, a tending*).

In the absence of orthophoria there may not be any actual turning of one visual line away from the other, but there is a tendency on the part of one or more of the eye-muscles to disturb the balance. Should the nervous control be so removed as to permit of the consummation of this tendency, actual deviations would occur.

Such disturbances of equilibrium are known, as above stated, as *Heterophoria.*

The deviating tendencies of heterophoria may exist in as many directions as there are forces to induce irregular tensions.

The following system of terms is applied to the various tendencies of the visual lines:

I. *Generic Terms.—Orthophoria:* A tending of the visual lines in parallelism. *Heterophoria:* A tending of these lines in some other way.

II. *Specific Terms.*—Heterophoria may be divided into—

1. *Esophoria:* A tending of the visual lines inward.

2. *Exophoria:* A tending of the lines outward.

3. *Hyperphoria* (right or left): A tending of the right or left visual line in a direction above its fellow.

This term does not imply that the line to which it is referred is too high, but that it is higher than the other, without indicating which may be at fault.

III. *Compound Terms.*—Tendencies in oblique directions may be expressed as *hyperesophoria*, a tending upward and inward; or *hyperexophoria*, a tending upward and outward. The designation "right" or "left" must be applied to these terms.

In recording the respective elements of such compound expressions we employ the sign ⌙. For example, if it is desired to indicate that the right visual line tends above its fellow 3°, and that there is a tending inward of 4°, the facts are noted thus: *Right hyperesophoria*, 3° ⌙ 4°.

It will be seen that deviating tendencies in every possible direction can be minutely and accurately described by such a system.

In seeking to discover these faulty tendencies the following method will be found convenient, and in the majority of instances satisfactory:

The subject of examination is to be seated with the head in what is known as the "primary position," in which the head is held erect and the face is turned exactly toward the object to be seen, so that a line passing from the object to the face would meet a line drawn between the eyes at its center and at right-angles to it.

The object to be looked at should be luminous against a dark background, a lighted candle being the best. It should be nearly upon a level with the eyes, and at a distance of twenty feet from them. If *ametropia* exists, it is to be corrected by appropriate glasses.

Under these circumstances there should be the

minimum of muscular innervation; that is, orthophoria should exist.

Orthophoria, or heterophoria, may now be determined by means of prisms in the following manner:

First of all, a prism of sufficiently high grade to induce diplopia is placed with its base toward the nose before one of the eyes. The two images of the object then seen are *homonymous*—that is, the right image is seen with the right eye, and the left with the left eye. If the two images are seen in exactly the same horizontal plane, no deviating tendency in this direction is manifest. If one of the images rises higher than the other, there is absence of equilibrium in this respect, and the condition is the one called *hyperphoria*. If in the test the left image of the object is seen higher than the other, it indicates that the visual line of that eye tends below that of its fellow, and that the visual line of the right eye has, in fact, a tendency to rise above the left visual line. This is *right hyperphoria*, and the state in which the right image is seen above the plane of the other is known as *left hyperphoria*.

If, as in the first instance, the left image is higher than the other, we determine the degree of right hyperphoria by finding the grade of prism which, placed with its base down before the right eye, or with its base up before the left, will bring the two images exactly to the same horizontal plane, and the result is recorded accordingly. Thus, if a prism of 2° base down before the right eye corrects the deviation from the horizontal plane, we write

Right hyperphoria, 2°.

It has been said that in determining the relations of the ocular muscles, glasses suitable for the correction of existing ametropia should be supplied. In testing for hyperphoria this precaution is not essential, and may, in general, be neglected, especially if the correcting-glasses should be strong. A very slight variation from exact adjustment of the optical centers of the glasses to the centers of the pupils might induce a degree of apparent hyperphoria, which, if real, would be of considerable consequence.

This test for hyperphoria should invariably precede all other muscular tests.

Next, diplopia is induced by placing a prism, with its base exactly up or down, before one of the eyes. In general, a prism of 7° is sufficient for this. If, after a moment, the images are seen exactly in the vertical line, no deviating tendency is shown. If, on the other hand, the upper image passes to the right or left of the other, heterophoria in this direction is shown.

The two deviating conditions which may now be discovered are:

Esophoria (ἔσω, *within*): A tending of the visual lines inward.

Exophoria (ἔξ, *out*): A tending of the visual lines outward.

If the deviations of the images are in the directions of the eyes to which they belong, the image seen by the right eye appearing most at the right and the image seen by the left eye at the left, the tendency is homonymous, and *esophoria* exists. If the image

seen by the right eye appears more to the left than its fellow, *exophoria* is shown.

If, in making this determination, a prism of 7° is placed with its base down before the right eye and diplopia is caused, the upper image will be the one seen by the right eye, the lower that seen by the left eye.

If, now, the upper image appears more at the right than the lower, it indicates esophoria; but if the image should be seen more at the left than the lower, exophoria would be shown.

In the same manner as in ascertaining the degree of hyperphoria, we determine the degree of exophoria or esophoria. The prism which brings and holds the images in the vertical line measures the defect.

Should both hyperphoria and esophoria or exophoria be found, the condition may be described by the compound term hyperesophoria or hyperexophoria. The degree of each element of heterophoria is indicated thus:

R. (or L.) Hyperesophoria, n° ⌞ n°.

If, in a given case, it should be found that the right visual line tends above its fellow 3°, and that the lines tend inward 4°, the facts are noted thus:

R. hyperesophoria, 3° ⌞ 4°.

The absence of indications of heterophoria does not, of necessity, prove orthophoria. Heterophoria, like hyperopia, may be latent, and considerable time and much patience may be required to ascertain the true state of the muscles. The conditions which are to be found by the methods described are *manifest*, not *absolute*.

Hence, hyperphoria 1° by the tests described may, at length, prove to be hyperphoria 3° or 4°. The tension at which the eyes are habitually held may continue in part or entirely to conceal the absolute tendencies.

This important fact that heterophoria may be manifest only in part should not in any case be lost sight of. Many examinations may be required to determine, even approximately, the absolute heterophoria. In a certain proportion of cases, latent heterophoria may become manifest by the use of nominally correcting prisms in the same manner as latent hyperopia sometimes becomes manifest after the use of weak convex glasses. Great caution is to be exercised in determining the latent heterophoria, that an apparent anomaly is not actually induced by the use of correcting-prisms.

It is possible, should one who has perfect equilibrium of the eye-muscles use prisms with the bases out for a few days, to find the conditions of esophoria in tests made immediately after removing the glasses. To assume that such a case is one of actual esophoria would evidently be a mistake. But should one who manifests 2° esophoria use a prism of 1° for a day or two, and then reveal esophoria of 3°, it would be quite safe to increase the prism to 2°; and should the excess of 1° over the correction continue several days, it would be safe to conclude that there is at least 3° esophoria.

Having determined the deviating tendencies by the methods described above, similar tests may be made at

reading distance. In these tests the method of Graefe is most conveniently employed. On a card, a fine, straight line is drawn through a dot (Fig. 12). Diplopia is produced as before, but prisms of considerably stronger grade may be required, when the observations are made in the same manner as when the test-object is situated at a distance. This test was used by Graefe for determining "insufficiency of the interni," and is the test described in text-books. The conditions found by it may be recorded as exophoria (or esophoria) *in accommodation.* Exophoria in accommodation corresponds to the condition described by Graefe and others as *insufficiency of the interni.*

Fig. 12.

All these determinations having been made with sufficient care, the examiner proceeds to ascertain the relative power of the different pairs of muscles by finding the strongest prism with which images can be united in different directions. To determine the strength of the abductors, the prism should be held with its base inward.

The standard of abduction adopted by the author is 8°. A prism of that grade should be overcome, and images of an object at twenty feet distance should blend. If the abducting power is less than this by two or three degrees, it is strongly suggestive of esophoria, even should esophoria not have been shown by the previous tests.

It is to be remembered that heterophoria may be partly or wholly latent, and the fact that no esophoria

is manifest is to be considered in its relation to the power of abduction.

Deficiency of abduction resulting from hyperphoria will be noticed below.

The power of overcoming prisms with the base up or down may be tried before or after the trial for abduction. Commencing with a very weak prism, we try stronger, until the strongest that can be overcome in one direction is found; then the strongest in the opposite direction. A prism with its base down before one eye is equivalent in its action to a prism with its base up before the other. The amount of power shown in overcoming a prism with its base down before the right eye is the degree of *right sursumduction.* If the prism is placed before the left eye in the same direction, or if it is turned with its base up before the right eye, it indicates the degree of *left sursumduction.* We can not make accurate determinations of both right and left sursumduction, if the test for one follows without interval after the other. It is, therefore, well to test in one direction before the test for abduction and in the other after it.

The average ability of overcoming prisms in this manner is about 3°. In high grades of myopia it may reach 8° or 10° in each direction.

Finally, the amount of adduction is to be determined. Prisms are to be placed before the eyes with the base out and the strength gradually increased until the images can no longer be blended. The highest grade of prisms overcome marks the adducting power.

The standard of adduction should be about 50°, but many, who after trials repeated daily for two or three times will accomplish an adduction to this extent, will not accomplish half the amount at the first trial.

All the tests for sursumduction, abduction, and adduction should be made at the distance of twenty feet.

HYPERPHORIA.

Hyperphoria is that condition in which, with the ability to maintain binocular vision, there is a tending of one visual line in a direction above that of the other.

Strabismus, in which there is an actual turning of the axis of one eye above the other differs from hyperphoria in the absence of ability to maintain single vision. *Strabismus sursumvergens*, and *deorsumvergens* were described and operative measures for their correction were long since pointed out. Special attention was first called to the condition of hyperphoria as an important and frequent anomaly of the ocular muscles by the author of this work.

Among the anomalous tendencies resulting from faults of equilibrium of the eye-muscles, hyperphoria is of pre-eminent importance.

A slight deviating tendency in this direction is often of greater account than one of a considerable degree in others.

The ability of the eyes to adjust the visual lines for the correction of a difference in their direction in the vertical meridian is much less than that for correcting a similar difference in the horizontal line. It has been

already shown that the power to overcome a prism placed with its base up or down before an eye is usually limited to about 3°, while in abduction a prism of 8° and in adduction prisms of 50° may be overcome when the normal standard of power in these directions exists. It is evident, therefore, that a deviating tendency of 1° or 2° in the direction of hyperphoria creates an excessive demand for correction upon muscles illy calculated to perform the duty.

A still more important element in the results of hyperphoria is its influence upon the action of the lateral muscles.

In hyperphoria the eyes may be so influenced in their movements that, when directed to a distant object at the same height as the eyes, there is a strong tendency of the visual lines inward (esophoria); but if directed to a near object, especially if it is below the plane of the eyes, the visual lines swing outward, causing a very marked exophoria in accommodation, or, as it is familiarly known, insufficiency of the interni. Many of the most intractable cases of insufficiency of the interni are the result of this swinging movement of the eyes, and it is not rare to see asthenopic persons who are armed with powerful prisms for the correction of insufficiency of the interni, who have no other muscular error than a slight hyperphoria.

Persons subject to hyperphoria are much more liable to be troubled with double images than those subject to simple exophoria or esophoria.

Vertigo and confusion of vision are extremely common symptoms of hyperphoria. Persons affected by

this anomaly, if weak or in ill health, often experience a dread of walking in crowded streets unattended, fearing that they may fall or suffer from mental confusion in the crowd.

The attitudes and facial expressions of hyperphoria, while not universal, are quite characteristic. The head is, in a very considerable proportion of cases, carried habitually toward one shoulder. If the right eye tends higher than the left, the head is carried to the left shoulder; if the left eye tends above, the head is at the right.

The efforts made by the eyelids to aid in forcing the eyes in position give certain peculiarities to the facial expression. One eye may appear partly closed, or both eyes are opened very widely with a kind of stare which has been described as "the hyperphoric stare."

The eyes in hyperphoria have, in many instances, an unsteady gaze. One eye may appear to float away from the other and then back again.

Vision is, in a considerable proportion of cases, affected. It has been found that, in more than fifty per cent of cases, vision is less than two thirds the normal standard.

Many cases of abnornal secretion of tears have their origin in this condition. They do not yield to the ordinary methods of treatment for such complaint, and are liable, by means of the excessive flow of tears, to result in distention of the lachrymal sac and in inflammation of the lining membrane of the nasal canal, leading to its contraction.

In its reflex results hyperphoria is an extremely im-

portant element in neuroses. Especially in epilepsy and vertigo should it be looked for with great care.

TREATMENT OF HYPERPHORIA.

The best treatment for hyperphoria is tenotomy of the muscle which forces the eye out of its proper direction. It is not always easy or even possible to determine to which muscle we are to attribute the vicious tendency. The superior rectus of one eye may be short, causing too great tension upward, or the inferior rectus of the opposite eye may be at fault, tending to draw the eye downward, or one of the four oblique muscles may cause the loss of equilibrium. With all these elements of uncertainty, the highest skill of the surgeon may be demanded in forming a correct conclusion. A complete knowledge of what is known of the physiological action of the various eye-muscles is essential in this examination. In the majority of cases, however, in which the hyperphoria does not exceed three degrees, it is proper to relax either the superior rectus of the eye of which the deviating tendency is upward or the inferior rectus of the other. In general, it will be found best to select the superior rectus. If more than three or four degrees of deviating tendency is found, it is better to correct a part upon the superior rectus of one eye and what remains of the defect upon the inferior rectus of the other eye some days later.

The method of performing tenotomy in these cases of deviating tendencies less than strabismus has been

* See page 135.

already described.* Since submitting this method to the Royal Academy, however, I have found it advisable to modify the procedure somewhat, rendering the operation more simple and the results more satisfactory. As now performed, the eyelids being retracted, a fold of the conjunctiva is seized by a fine but rather rigid pair of mouse-tooth forceps, parallel with the course of the muscle and exactly over its insertion. With a pair of small, narrow-bladed scissors, having blunt but very perfectly-cutting points, a transverse incision is then made through the membrane exactly corresponding to the line of insertion of the tendon. The conjunctival opening thus made should not exceed in extent one fourth of an inch. With the forceps now pressing the outer cut edge of the conjunctiva slightly backward toward the course of the tendon, the latter is seized behind, but very near its insertion. The distance may depend upon the freedom with which the intended section of the tendon is to be made. But in hyperphoria, or in slight relaxations of the lateral muscles, a distance barely sufficient to allow a small part of the tendon to be raised from the sclera is all that should be allowed. Making some tension now with the forceps, the points of the scissors are directed against the central portion of the tendinous insertion and toward the sclera, when a small opening is made dividing the center of the tendinous expansion exactly on the sclera. The small opening is now to be enlarged by careful snips of the scissors toward each border, keeping more carefully on the sclera as the border of the tendon is approached. As the section of

the tendon is carried toward the borders, the outer blade of the scissors passes beneath the conjunctiva. If the relaxation of the tendon is to be slight, the extreme outer fibers of the tendon are to be preserved untouched, but if a considerable effect is desired these fibers can be entirely severed, provided that the reflection of the capsule of Tenon upon the tendon is not disturbed. By means of the capsule acting as an auxiliary attachment, the tendon is held in position but is allowed to fall back slightly while maintaining its relation to the eyeball. In this respect, and in preserving the outer tendinous fibers, this operation differs radically from the ordinary operation for strabismus, and from any operation which has been proposed for so-called "partial tenotomy" of the recti muscles.

The judgment of the operator must determine the extent to which the division should be carried; but, should it be found that too little has been accomplished, the section can be extended. In doing this, the use of a very fine hook may be advisable. For this purpose a hook very much smaller and more delicate than the ordinary tenotomy-hook should be employed. Its rounded point is carried under the remaining border of the tendon with great care to prevent hæmorrhage or unnecessary disturbance of the connective tissues, the extension being made toward one and then toward the other border, as the demand for further relaxation may require. When the remaining band of fibers is made tense by the hook, it is slightly elevated from the sclera, when the fine-pointed scissors are introduced beneath the conjunctiva, and

the necessary extension of the wound is made with an extreme caution not to divide the capsular attachment. The conjunctival suture should in no case be employed. All bandaging of the eye or covers of any description are not only needless but mischievous. Bandages are promoters of heat, filth, and septicism.

ESOPHORIA.

Esophoria, or "insufficiency of the externi," is an exceedingly common and a very troublesome anomaly of the ocular muscles. In esophoria the relative tension of the eye-muscles is such that, if the force of the will were to be removed, the visual lines would approach each other and cross at a point less distant than that for which the eyes are accommodated. In strabismus convergens this tendency is carried to the extent that one visual line constantly deviates from the direction of the other. In esophoria there is habitually an ability to bring the lines simultaneously to the same point. The effort required to continue this adjustment may be, and in the great majority of instances is, made without the direct consciousness of the individual, and there is not of necessity any appearance of deviation, although it is not uncommon to observe an appearance of insufficient distance between the eyes—giving, in this respect, a narrow facial expression disproportionate to the general features.

Graefe, in his extensive writings upon the ocular muscles, devoted only a passing notice to this condition, his treatise on muscular asthenopia containing but a single paragraph relating to it. In this, how-

ever, he was more liberal than most succeeding writers, and even the latest text-books on ophthalmology make no reference to the condition. The first notices of cases of treatment of "insufficiency of the externi," in which no strabismus existed, and in which important results were obtained, were reported by myself in various papers from 1876 forward. In the memoir to which this discussion is supplemental, more especial consideration was devoted to this condition than had been given to it in all previous writings, and the many instances of remarkable relief obtained from the correction of this anomaly related therein precede any considerable discussion of the subject, and, indeed, constitute the principal contribution to it up to the present time.

"Insufficiency of the interni" is the condition to which muscular asthenopia has been generally attributed. We have already seen that hyperphoria is an element of the first importance in muscular asthenopia, and a careful perusal of the foregoing memoir will convince the reader that esophoria is also of equal significance with, if not of greater importance than, "insufficiency of the interni." It is certainly of more frequent occurrence, and is, in a greater proportion of cases, attended with distant reflex disturbances.

Among the symptoms very commonly observed as resulting from esophoria, are pain in the back of the head and in the back of the neck. Such pains often succeed an hour's visit to a gallery of pictures, attendance at a public gathering, where one confines the gaze for a considerable time upon a speaker; and travel in a

rail-car, when the individual, the subject of esophoria, looks out upon the rapidly-changing objects of the landscape, is often the precursor of such occipital headaches.

Nervous exhaustion, palpitation of the heart, pain between the shoulder-blades and at the lower part of the back, dyspepsia, and habitual constipation are among the very common reflex nervous phenomena resulting from esophoria.

To ascertain the existence of esophoria and its degree, the test for hyperphoria having been already made, we first place a prism of about 7° with its base down before one of the eyes and cause the person examined to look at an object twenty feet distant. Double vision results with the image before which the glass is placed above its fellow. If, now, the higher image deviates in the direction of the eye before which the glass is placed, if the deviation is homonymous, there is esophoria, measured by the degree of prism, placed with its base out before either eye, which brings and holds the two images exactly in the same vertical line. In making this examination hyperopia or hyperopic astigmatism, if of higher grade than ·50 D, should be corrected by appropriate glasses. Moderate degrees of myopia or myopic astigmatism have little influence upon the test. After determining the degree of esophoria by the vertical prism, the amount of abducting power is to be ascertained. Prisms with the base in are employed, requiring the person examined to make the strongest effort to blend the double images. The strongest prism which can be overcome marks the

power of abduction. This power should be equal to overcoming a prism of 8° with the base in.

Let us suppose that esophoria of a certain degree has been found, and that there is approximately a corresponding restriction of the abducting force. The diagnosis of esophoria of the given amount is clear. But if, by the vertical prism, no deviation is shown, and there is still a restricted abduction, there is probably latent esophoria equal, at least, to the difference between a prism of 8° and that with which images can be blended.

But let it be supposed that a very considerable degree of esophoria is found with a power of abduction exceeding the standard given above. One of two conditions must be presumed: There may exist an actual deviating tendency inward, and by constant efforts at its correction the power of the external recti may have been so greatly developed as to enable the individual to accomplish more than the usual abduction; or, more probably, there exists hyperphoria. In this later case the esophoria may be apparent, the result of a swinging movement given to the eyes in the test, and the actual balance may be neither inward nor outward. The utmost caution and great patience are required in the management of this class of cases. A condition exactly opposite the one just supposed will be considered in the discussion of exophoria. Again, should esophoria be found when testing for the distant point, and exophoria be shown in accommodation, we are to suspect hyperphoria, and the case should be carefully observed until this question is satisfactorily deter-

mined. After having made the examination at the distance of twenty feet, examination with the vertical prism is made at a distance of about eighteen inches. If esophoria is found, it is esophoria in accommodation.

TREATMENT OF ESOPHORIA.

Esophoria may, under certain circumstances, be treated by prismatic glasses; if refractive errors exist, the prismatic element may be combined with the spherical, or cylindrical glasses.

This is the method of a crutch, and is inconvenient and by no means uniformly successful. Indeed, successful relief to esophoria, by means of prisms, would appear to be rather exceptional. It is a proper method of treatment only when better methods can not be adopted. There are several reasons in the nature of such a correction why it should be unsatisfactory, which need not be discussed here.

The radical and best method is tenotomy of one or both of the interni, performed by the method already described at page 203. Before resorting to an operation it is always advisable that the power of adduction should be fully developed in the manner that will be shown in the section on exophoria. An adducting power of 50° should be shown prior to the operation.

EXOPHORIA.

This is the condition which has been described in text-books as "insufficiency of the interni." The condition, however, differs in the respect that, whereas "insufficiency of the interni" has, by Graefe and in

the text-books generally, been determined by the dot-and-line test at a near point, exophoria is the condition found at a distance when no accommodation is employed. The condition described in text-books is here known as exophoria in accommodation. The conditions found by the tests known as the "cover-tests," and by holding an object near the eyes to observe the deviation of one or other, are perhaps better included in the limits of the subject of strabismus.

Exophoria is discovered by means similar to those described for esophoria. If, with the vertical prism, the images cross, if the image seen by the right eye is at the left, and that seen by the left is at the right of the other, exophoria exists in the degree measured by the prism with its base inward, required to bring the two images to a vertical line.

Exophoria in accommodation is tested in the same manner, but at the near point. If, with a certain degree of exophoria, abduction exceeds 8°, we have an undoubted condition of deviating tendency outward. If, on the other hand, exophoria is attended with restriction of abductive force, we are to presume that hyperphoria exists, and that, as in the case of esophoria, under the reverse conditions, the apparent exophoria is the result of the swing resulting from the hyperphoria.

Exophoria in accommodation is often associated with esophoria, and should never under such circumstances be mistaken for an actual tendency of the eyes to deviate outward.

The symptoms of exophoria are, perhaps, more fre-

quently than esophoria, local. As a result of this anomaly, the condition of muscular asthenopia is common, and is indeed the only condition usually associated with this anomaly in the literature of ophthalmology.

In muscular asthenopia there is a sense of painful fatigue of the eyes after close work or reading; an inclination for the letters or words of the page to run together, or for one word to find itself superposed upon another. A feeling of tension and dull pain over the brows and in the back of the head is experienced, the latter, perhaps, more especially after a few hours have elapsed since the use of the eyes.

The more distant manifestations of exophoria are the neurasthenic symptoms, which have already been mentioned as resulting from other forms of heterophoria. It may be accepted as a general fact, however, that the symptoms of exophoria are more likely to be local, those of esophoria more general. The effort made in exophoria to hold the visual lines in adjustment for reading or other close work results in local fatigue and pain. That made in esophoria is attended with less local strain at the moment, but is a perpetual source of disturbance of the relations between the accommodative and converging forces. It is a condition of nervous perplexity, experienced both when looking at near and far points.

In the diagnosis of all these conditions of hyperphoria, esophoria, and exophoria, we are in every case to take into account the fact that the manifest condition does not always represent the absolute deviating tendency.

Graefe, and many who have followed him, regarded insufficiency of the interni as a condition found mostly with cases of considerable myopia. If we accept the test at the near point as indicating such insufficiency, it may be true that the condition is so frequent with myopia as to be peculiarly an associated state; but exophoria as here described is less frequently found with myopia than is esophoria.

In the condition of orthophoria the adducting power should be equal to an ability to overcome prisms amounting to 50°, when the object is placed at the specified distance, twenty feet. Even eyes with well-balanced muscles may not, in the absence of a certain muscular facility, be able to accomplish this at the first trial. A few attempts will generally be rewarded with complete success. In exophoria the abducting power may be much less than this, and when a considerable reduction of this force is associated with exophoria, as shown by the vertical-prism test, it is an additional evidence of the vicious tendency. Insufficient adducting force is not, however, always indicative of exophoria, nor is it always an element of exophoria. Indeed, in many cases of very considerable outward deviating tendency, the power of adduction is exercised with remarkable vigor and to the full extent that can be desired. On the other hand, a feeble abducting power may be found where there is no exophoria, and where even esophoria of high degree exists. In these cases the failure of abducting power may arise, among other things, from fatigue of the muscles or from disuse. This latter reason is pecul-

iarly marked in certain cases of esophoria. In such cases there has been, during the history of the patient, little need of performing a positive act of adduction. Habitually the external muscles have by severe tension, maintained the parallelism of the visual lines, and when it is required to converge these lines the act is performed, not altogether by the muscular contraction of the interni, but largely by their natural elasticity, acting when the opposing tension of the externi is removed.

TREATMENT OF EXOPHORIA.

In the condition of insufficient abducting power, such as may be found with moderate exophoria, with no especial deviating tendency, or with esophoria, the adduction may be greatly improved by gymnastic exercises of the interni conducted by the aid of prisms.

In these exercises the eyes are required to unite images in overcoming gradually increasing obstacles. A prism of a few degrees, perhaps 10°, is placed, base out, before one of the eyes, while gazing at a lighted candle placed at twenty feet distance, when an effort is at once made to prevent diplopia. As soon as the images are blended, another prism, of perhaps less degree, is placed in the same manner; the images being united, a stronger prism takes the place of one of those already in place, or one is added to those already in position. Thus, little by little, the eyes are required to overcome prisms until the images can no longer be united. Then all the glasses are removed and the process is repeated; with each repetition something may be gained. The exercise should

not be continued at a single sitting more than five or six minutes, and only a single sitting daily is desirable.

By this means the adducting power can, in most cases, be raised after a few exercises to the desired point. It is an interesting fact that in most cases of moderate exophoria, or of no especial heterophoria, the exercise is attended with much more speedy results than in a certain proportion of cases of esophoria.

The effect of such exercises upon the eyes is very often extremely salutary. With greater freedom of muscular action comes a sense of relief from nervous strain, which is often of a most gratifying character. Such an exercise is in no way related to the practice sometimes adopted, and which should be condemned, of requiring the patient to gaze for a length of time at a near object. In this latter case the act of accommodation is associated with the convergence of the optic axis, and there is simply an exaggeration of the accustomed strain. In the exercise with prisms the accommodation is at rest, and the action of the recti muscles is almost completely dissociated from that of the ciliary muscles. The exercise then selects the muscles to be acted upon.

In exophoria of a moderate degree, prisms with the base in may be found useful in reading. It is in this condition, of all the forms of heterophoria, that prisms are most likely to prove of any permanent use. In general, even for moderate exophoria, a radical relief is to be preferred to the perpetual employment of glasses.

The method for performing tenotomy, as described

already, should be followed closely in this as in other conditions of heterophoria. The advice given by Graefe, and followed up to the present time in the text-books, to sever the externus completely and to induce homonymous diplopia, is not to be followed. Graefe performed his operations, for the most part, in cases of extreme myopia. In these cases, the vision of his patients being defective at a distance, an insufficiency of the externi did not appear to be a matter of serious consequence. It may well be supposed also that, for the most part, his cases were not of the class which has here been described as exophoria, but cases of positive but slight strabismus.

The result of a tenotomy for exophoria should not be homonymous diplopia, nor even esophoria to exceed 1° or 2°, and the abducting power should immediately after the operation not be less than sufficient to overcome a prism of 6°. Should exophoria again manifest itself, the operation may be made upon the opposite eye; and it is better to make repeated operations than in any instance to obtain diplopia or considerable esophoria.

The study of muscular anomalies, in which gross deviations are found, strabismus concomitans, or strabismus from paralysis, constitutes a subject of much interest to the student of the effects of ocular anomalies upon the nervous system. Cases of this class are much less frequent than those already discussed, and, to a considerable extent, the principles which have been laid down respecting the more ordinary class of anomalies will apply to non-paralytic strabismus.

It is the purpose of this supplement only to introduce the practitioner into a field not usually investigated, except by specialists, and to assist him in his efforts to find and to remove a class of causes largely instrumental in inducing an important class of disorders.

To add largely to what has been said would be outside the design of this work. The author, therefore, reserves the discussion of his personal views upon strabismus for a future work upon the ocular muscles.

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